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SUDAN GOVERNMENT

AGRICULTURAL RESEARCH WORK IN THE SUDAN.

Reports for the Season 1926-27, and Programmes for the Season 1927-28

Issued, with the consent of the Sudan Government,
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REPORTS FOR THE SEASON 1926-27 AND PROGRAMMES FOR THE SEASON 1927-28

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REPORT ON AGRICULTURAL RESEARCH SEASON 1926-27 AND PROGRAMMES OF WORK FOR 1927-28

SUBMITTED TO
THE LONDON SUPERVISORY
COMMITTEE
OCTOBER, 1927.

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AGRICULTURAL REPORT ON THE GEZIRA IRRIGATION SCHEME, SEASON 1926-27

BY

R. HEWISON,

Director of Agriculture and Forests.

I.—GENERAL.

THREE more blocks were brought into cultivation this season—viz., Tebuub and Abdel Rahman on the north-west, and Radma on the western boundary.

The Wad Sulfab block to the north was also increased, bringing the total irrigated area up to 300,000 feddans.

No changes in rotation or in general agricultural practice were introduced during the season.

RAINFALL.—The rainfall was very slight, the total precipitation amounting to 9·2 inches at the Gezira Research Farm.

A lower rainfall than this has occurred only once since Tayiba was started in 1911-12.

The tenants generally did good work.

Much supervision is required to maintain a fair standard, particularly in connection with watering and picking, but in view of the lack of experience of most of the cultivators, this is not remarkable.

SEED of similar origin to that sown in the previous year was used.

With the exception of an unusually cold spell in November the climatic conditions during the season were generally favourable to the development of the cotton crop.

PESTS.—The general incidence of pest infection was slight.

Blackarm, Thrips, and other diseases and pests were present at various stages of the crop, but did not do any very great damage.

II.—COTTON CROP, 100,057 FEDDANS.

The total yield, area, and rainfall, compared with previous seasons, are given on p. 6.

Season.	*Area (Feddans).*	*Kantars* per Feddan.†*	*Rainfall (Inches).*	*Remarks.*
1911–12	250	5·32	13·2	Medani rainfall.
1912–13	610	5·62	11·9	„
1913–14	668	3·80	14·6	„
1914–15	2,963	5·29	9·0	Barakat started.
1915–16	3,361	3·32	13·6	—
1916–17	4,301	3·31	18·5	—
1917–18	3,855	3·29	17·4	—
1918–19	3,964	3·33	11·4	—
1919–20	3,756	5·26	12·2	G.R.F. rainfall.
1920–21	3,711	3·27	23·2	„
1921–22	9,818	3·92	13·4	Hosh started.
1922–23	10,386	3·66	22·7	—
1923–24	22,496	2·86	17·4	Wad el Nau.
1924–25	21,616	2·21	14·6	—
1925–26	80,301	4·79	11·1	Dam functioned.
1926–27	100,057	4·74	9·2	—
Total 16		Average 3·99	14·6	

The individual block yields were:

Block.	*Area (Feddans).*	*Origin of Sakel Seed.*	*No. of Cotton Crop.*	*Kantars per Feddan.*			
				1926–27.		1925–26.	
1. Ghubshan ..	4,672	Egypt	1	5·78	4·68	6·38	South area, 4·92
2. Wad Naaman ..	5,230	Gezira	1	5·20		6·00	
3. Hosh	3,929	„	2	3·79		3·67	
4. Remitab ..	4,710	„	1 and 2	4·22		3·90	
5. Wad Atai ..	5,140	„	1	4·41		4·61	
6. Kumour	5,043	Gezira	1	4·67	4·55	4·93	Central area, 4·65
7. Hamad el Nil ..	4,382	„	2	3·92		4·67	
8. Barakat	3,455	„	4	3·47		3·82	
Seed Farm ..	1,280	Various	2	4·60		3·49	
9. Darwish	5,174	Gezira	2	4·02		5·01	
10. Abdel Hakam ..	4,610	Tokar	1	5·17		5·05	
11. Medina	5,254	Gezira	1	5·64		5·62	
20. Radma	3,168	Egypt	1	4·92		—	
12. Tayiba	7,350	Gezira (2 years)	6 and 1	4·53	4·94	4·57	North end, 4·57
13. Selama	4,721	Tokar	1	4·71		4·69	
14. Tebuub	6,323	Gezira	1	5·32		—	
15. Galeel	4,186	„	1	5·01		4·50	
16. Sadulla	4,542	„	1	4·97		3·88	
17. Abdel Rahman ..	4,400	„	1	6·03		—	
18. Nidiana	5,849	„	1	4·83		4·76	
19. Sulfab	6,639	„	1	4·10		5·04	

* Unless otherwise stated, a kantar=315 rottles of seed cotton—*i.e.*, approximately 100 lbs. of lint.

† 1 feddan=1·038 acres.

The following figures give the amount picked per feddan each month, but are not strictly accurate, as an estimate has to be made of the amount picked by the tenants, but not actually weighed in, at any particular date:

	January.	*February.*	*March.*	*April.*	*May.*	*Total.*
1925–26 ..	1·21	1·39	1·40	0·51	0·28	4·79
1926–27 ..	1·16	1·43	1·40	0·60	0·15	4·74
Difference ..	−0·05	+0·04	—	+0·09	−0·13	−0·05

The final average yield of 4·74 kantars seed cotton per feddan compares with the previous season's figures of 4·79.

The quality of the lint was, however, considered to be better on the whole, while the ginning return was higher. On a general comparison with the previous season it may be said that there were fewer exceptionally good areas, and less very bad cotton, and a better general average.

III.—DURA, 50,188 FEDDANS.

The bulk of the dura grown was *feterita*, though small areas of other varieties were tried in various places. *Feterita*, however, gave the best general results, and until a more suitable type is introduced is likely to continue to be the favourite dura for this area. A certain amount of damage was done to the dura crop by late rains which fell in October and November. The dura crops received an average of three waterings. A fair estimate of the yield per feddan would be about $1\frac{1}{2}$ Gezira ardebs—*i.e.*, 840 rottolis.

As the cultivators become more experienced in the growing of dura as an irrigation crop, it is likely that more careful watering, and better spacing of the plants, will result in better crops being grown.

IV.—LUBIA, 50,000 FEDDANS.

The lubia crop on the whole was a very good one. Many very finely-grown fields were to be seen, and it is observed that the tenants are taking much more interest in this crop than was formerly the case. The watering of lubia ceased at the end of December, except in the case of a few small areas especially required for the feeding of working animals.

V.—LIVESTOCK.

Owing to the scarcity of grazing elsewhere there was a very large influx of livestock from the White Nile Province and the northern districts of the Blue Nile Province into the irrigated area. With the animals kept by the tenants these were more than enough to consume all the dura stalks and the lubia produced.

It is observed that a certain proportion of the tenants are beginning to stack their forage against the inevitable period of scarcity. In the majority of cases, however, such measures were not taken, with the result that most of the holdings had no forage at all left by the end of May.

The health of livestock throughout the area was generally good, and until the end of May their condition was excellent.

VI.—LABOUR.

There was a plentiful supply of labour throughout the season. Owing to the failure of the rain crops large numbers of the inhabitants of the White Nile Province, and the northern districts of the Blue Nile Province, migrated into the irrigated areas and competed with the West Africans during the picking season.

VII.—STATISTICS AND RECORDS.

In conjunction with the Sudan Plantations Syndicate, arrangements have been made for the collection of comprehensive data regarding the individual 10-feddan plots into which the irrigated area is divided. Forms have been printed which are being filled in from the records kept by the Syndicate at their Block and Headquarter Offices. As soon as the filling in of the first series is completed, which should be about the end of this year (1927), the question of how this data can be most effectually treated will be gone into.

In the meantime the Statistical Section of the Rothamsted Experimental Station is being consulted as to the most suitable methods of dealing with the mass of detailed information which is being collected.

GEZIRA RESEARCH FARM—WAD MEDANI NINTH ANNUAL REPORT, 1926-27

BY

V. P. WALLEY,

Chief Inspector in Charge of the Farm.

I. INTRODUCTION.

Considerable progress has been made during the season in equipping and bringing this Station up to date. The layout of plots and their replication has been arranged so as to comply with recent improvements in the running of field experiments.

The British staff has been well housed. Two Grade II. houses have been built during the season, making now a total of six houses. With the completion of three additional clerk's houses and eight masonry tukls now being built the other staff will also be well provided for. A rest-house will be built during the coming season to accommodate visitors, more especially research workers from other countries.

A good well-water supply has facilitated laboratory work, and with the additional electric power now proposed, future requirements will be met for some years to come.

Entomological Section.—Mr. H. B. Johnston took over the Entomological Section from Mr. H. W. Bedford in October, 1926. The work of the section has chiefly been confined to the study of Gezira cotton and dura pests. Parasitization as a means of control is suggested. Special studies of white ants and thrips have been carried out by Mr. Whitfield and Mr. Cameron. A separate report on this work will be submitted by the Entomological Section.

Chemical Section.—Soil problems are demanding more and more attention. The collecting and analyzing of soil samples from the whole area involves a considerable amount of travelling and work. This, in addition to much more detailed examination of the farm plots, has necessitated the appointment of a second chemist, Mr. R. K. H. Peto, who arrived in November, 1926.

Work on the salt content, salt and moisture movement and nitrates, is being studied in relation to plant growth. The beneficial effect of heavy applications of gypsum on moisture movement has

been so striking that results justify an experiment being carried out on a very much larger scale. A full report on this department's work will be submitted through the Government Chemist, Khartoum.

Botanical Work.—This has been carried out under the supervision of Mr. A. R. Lambert in collaboration with the Government Plant Breeder and the Government Botanist. Observations on the cotton plant have been made at all stages of its growth, so as to obtain a true picture of its life-history in the Gezira. An endeavour has been made to trace the effect of climate and other factors on the plant growth. A separate report is submitted on this work (see p. 33).

II.—FARM CROPS.

Cotton.—Area, 122$\frac{1}{6}$ feddans; seed, Sakel from Tokar. The average yield was the second highest since the Farm was first started.

	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.
Kantars per feddan ..	3·92	3·25	2·59	3·06	3·35	3·15	1·81	2·45	3·86

This increase in the yield is largely due to the improved condition of the soil brought about by the keeping of more animals on the land. Some of the best subplots have yielded as much as 7 kantars per feddan. The general average is, however, reduced by the inclusion of the yields from continuous and two-course rotation plots. It is interesting to note that the Farm yield is 0·4 kantar better than that of the Barakat block adjoining. Another factor that has had a good effect on the yield has been the date of sowing. Prior to this season, it had been the custom to sow between July 20 and August 15. Experiments last season showed that the optimum date was about August 20. Sowing this season was therefore done between August 15 and 30. By watering before sowing, a good stand of plants was again obtained.

The following figures show how the cotton came in as compared with other seasons:

Month.	*Kantars per Feddan.*					
	1926–27.	1925–26.	1924–25.	1923–24.	1922–23.	1921–22.
	%	%	%	%	%	%
December ..	0·11 (3)	0·19 (7)	0·10 (5)	0·25 (8)	0·04 (1)	0·04 (1)
January ..	1·98	1·08	0·44	0·83	1·13	0·99
February ..	1·34 (93)	0·66 (87)	0·50 (69)	1·06 (79)	1·37 (86)	1·11 (85)
March	0·28	0·40	0·31	0·59	0·36	0·47
April	0·11	0·09	0·23	0·24	0·15	0·23
May	0·04 (4)	0·03 (6)	0·23 (26)	0·18 (13)	0·30 (13)	0·22 (14)
Total ..	3·86	2·45	1·81	3·15	3·35	3·06

It will be seen from the above figures that, in spite of being sown twenty days later than was usual, the crop was distinctly earlier than last season. The quality of the cotton was not quite up to last year's standard, possibly owing to adverse climatic conditions, which brought on plant asal.

Lubia.—Area, $23\frac{7}{12}$ feddans. This was sown before the cotton crop. The first growth was well up to average and was cut about October 5. The second growth was very poor owing to the exceptionally cold winter. A very good crop of seed was taken.

Dura.—Area, 82 feddans. The main crop was an early maturing dwarf *feterita*. It only yielded moderately well. It is proposed to discontinue growing this variety in the future and to go in for a dura which will produce a large bulk of forage in addition to being a good grain yielder. There is a serious objection to growing an early maturing dura, unless one's neighbours likewise grow it, on account of the damage done by birds.

The Farm crop had a very good stand, but suffered later through being sown too thick and not being given the right amount of water at a critical period. All the seed was successfully treated with formalin against smut (Arabic *sueda*).

III.—METEOROLOGICAL CONDITIONS.

Rainfall.—This was again very light. Showers during October and early November did much to make the humidity curve less severe, and no doubt were partly responsible for the excellent cotton yield.

Period.	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Total.*	*Ins.*
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Average of first seven seasons	12·3	36·3	120·7	181·5	56·5	8·7	0·0	416·0	16·6
1925	2·0	53·3	92·4	61·2	42·2	22·8	5·2	279·1	11·1
1926	13·7	6·0	73·5	105·0	23·5	7·0	1·8	230·5	9·2

Air Temperatures.—These have differed mainly from last season's in the following respect:

	November, December: Main Flowering Period.	*January, February: Bulk of Cotton picked.*
1925–26 ..	Temperatures rather above normal.	Temperatures abnormally low.
1926–27 ...	Very low temperatures, growth completely checked.	Temperatures high.

Had these low temperatures not occurred during November and December, it is thought that last season's yield for the Gezira would have been easily surpassed. The secondary growth which usually begins before the end of December was completely checked by the low temperatures.

AVERAGE MONTHLY MINIMUM (° C.).

Season.	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*March.*
1925–26	23	22	22	22	18	16	13	15	17
1926–27	23	23	22	22	16	15	16	15	17

HUMIDITY: AVERAGE MONTHLY FIGURES COMPARED WITH LAST SEASON.

Season.	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*March.*
1925–26	83	70	62	47	37	41	29	22	17
1926–27	67	71	62	46	24	36	42	27	23

It will be observed that the humidity during November and December was much less this season than last. For a complete graph of meteorological conditions see Appendix.

IV.—DISEASES AND PESTS.

A detailed account is given in the Assistant Government Entomologist's report (p. 114) Purely as general observations the following points are of interest:

BLACKARM.—Practically non-existent—at least, in the early stages of the crop. Later plants on poor areas developed it, but were not badly infected. The use of healthy seed plus favourable climatic conditions seems to have had a good effect.

THRIPS.—Were severe in isolated areas during November, December, and January. No effective means of control has yet been found except heavy flooding.

PINK BOLLWORM.—Infestation light. Towards the end of the season it increased to a rather higher percentage than last season. Damage done was in no way serious.

V.—LIVESTOCK.

The Farm stock has been increased by the purchase of one half-bred bull (Holstein × Shorthorn Beladi) and four heifers (Beladi × Egyptian) from the Veterinary Department The total head of

stock supported throughout the season on the Farm plots was 40 cattle and 100 sheep. This number of animals on a forage area of 100 feddans (dura and lubia crops) works out at 2·6 sheep per feddan per year. No outside food was bought. Crushed cotton seed, dura, and lubia have been used as concentrated foods. It is proposed to retain here a nucleus herd of dual purpose cattle, always having a well-bred stock bull available for serving any good type Beladi cows that are produced. The general health of the stock has been good throughout the season.

VI.—EXPERIMENTAL WORK.

(*a*) Rotations.

(i.) *Continuous Cotton : Plots* 4, 5, 8.

Plot 4.—The yields from this plot to date, without treatment, have been as follows:

	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.
Kantars per feddan ..	3·62	2·22	1·60	1·61	1·51	1·88	1·29	1·96	2·00

The plants were small and spindly, and as in previous seasons they were more susceptible to disease and pests.

Practically no cotton was picked from these plots after March 30.

The tilth of the soil in this plot is still comparatively good, and it is also fairly free from weeds.

Treated portions of this same plot yielded:

	Kantars per Feddan.
With 400 rottles of sulphate of ammonia per feddan: half at sowing, half six weeks later	3·41
With F.Y.M.: 3,600 rottles of dura stalk, 150 rottles of dura grain (fed to sheep)	3·16
With gypsum: 1 ton per feddan	2·14
With control	2·00

It is interesting to note that the sulphate of ammonia subplots were very little behind the original yield of 3·62 kantars, whilst the F.Y.M. plots have crept up thus:

	1924–25.	1925–26.	1926–27.
Yield	1·27 kantars	2·56 kantars	3·16 kantars
Percentage of control ..	—	130	158

This plot has now had treatment more than equivalent to that which land would have had under twenty-seven years of the present Gezira rotation. There appears to be no marked increase in salts.

Plot 5.—Without treatment. Its yields to date have been as follows:

	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.
Kantars per feddan ..	3·65	2·04	1·87	1·95	Lubia	Fallow	1·55	1·98	2·26

Like Plot 4 its crop has been more subject to disease and pests than three-course rotation cotton.

Each ungia (20) was weighed separately, and gave a P.E. of 7 per cent. compared with 11 per cent. last season.

Plot 8.—Without treatment. Yield to date:

	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.
Kantars per feddan ..	3·05	2·00	2·70*	2·43	Fallow	Fallow	2·03*	Fallow	3·44

It is proposed to continue with these two plots without treatment, so as to have sufficient area of uniformly played out land for manurial and other treatment at some future date.

These continuous cotton plots are of such extreme interest and usefulness that they might be repeated elsewhere in the Gezira.

(ii.) *Two-Course Rotations: Plots* 1, 2, 3, 6, 7.

Plots 1, 2, 3.—To continue with last season's method of comparison:

Plot.	*Kantars per Feddan.*									*P.E.* 1926–27.
	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.	
1 North half	4·72	—	3·18	—	2·58	—	2·25	—	3·48	8
South half	—	2·72	—	2·67	—	3·97	—	2·60	—	
2 North half	3·91	—	3·08	—	2·87	—	1·48	—	3·42	7
South half	—	3·71	—	2·11	—	2·54	—	2·65	—	
3 North half	3·77	—	3·18	—	2·57	—	1·42	—	2·27	13
South half	—	3·09	—	1·97	—	2·62	—	2·23	—	

The cotton on Plot 3 required a fair amount of resowing; it was also most severely attacked by thrips and blackarm.

These rotations have been supplemented by a complete set of two-course rotations in Plots 6 and 7. Results from these will not be available until the end of next season.

* Manurial treatment between 1920–21 and 1921–22 and between 1924-25 and 1925-26.

PERCENTAGE OF FIRST SEASON CROP (AVERAGE).

Plot.	Kantars per Feddan.									P.E. 1926–27.
	1918–19.	'19–20.	'20–21.	'21–22.	'22–23.	'23–24.	'24–25.	'25–26.	'26–27.	
1 North half	100	—	67	—	54	—	47	—	73	82
South half	—	100	—	98	—	145	—	95	—	
2 North half	100	—	78	—	73	—	37	—	87	55
South half	—	100	—	56	—	68	—	55	—	
3 North half	100	—	84	—	68	—	37	—	60	67
South half	—	100	—	63	—	84	—	71	—	

Plot 1: Cotton—Lubia. *Plot* 2: Cotton—Fallow. *Plot* 3: Cotton—Dura.

Plot 7.—Effect of cotton following dura and lubia:

	Gads.	Yield (Kantars per Feddan).		Gads.	Yield (Kantars per Feddan).	
1925–26 ..	6, 7, 8	Lubia	—	9, 10	Dura	—
1926–27 ..	6, 7, 8	Cotton ..	3·03	9, 10	Cotton ..	2·54

These results are in conformity with those of previous seasons, the lubia-cotton rotation giving the better yield.

(*b*) WATER DUTY TRIALS.

Plots 31-35 *Inclusive.*—These plots produced the following yields:

	Yield.
500 cubic metres per feddan ..	4·74 kantars per feddan.
450 ,, ,, ..	4·66 ,, ,,
400 ,, ,, ..	4·97 ,, ,,
350 ,, ,, ..	4·77 ,, ,,
300 ,, ,, ..	3·63 ,, ,,

The cotton in all received seventeen waterings, but was only given the above fixed quantities from the sixth watering (October 21) inclusive onwards, instead of starting with the third, as in previous years.

Later waterings, six to seventeen, appear to have had very little effect on the final yield.

The 300 c.m. plot was originally a poor one.

Drying-out Experiment.—Plots 32-35 inclusive:

17 waterings,	last on	April 7,	yielded	4·50 kantars per feddan.
16 ,,	,,	March 23	,,	4·31 ,, ,,
15 ,,	,,	March 7	,,	3·98 ,, ,,
14 ,,	,,	Feb. 21	,,	4·12 ,, ,,

Resowing light.

From the above it appears that had irrigation ceased on February 21 the cotton yield would not have seriously suffered on this area in this season.

The increasing yield from the fourteenth to the seventeenth waterings was entirely due to new growth.

(*c*) Spacings and Thinning Cotton.

Plot 36*: Spacing* (80 *cms. between Ridges*).	*Yield* (*Kantars per Feddan*).	*P.E.* (*Percentage*).
30 cms. between plants	4·34	6
40 cms. „	4·37	6
50 cms. „	4·34	7
60 cms. „	4·27	5
70 cms. „	4·17	2

Resowing light.

So little difference has been obtained with the above spacings that it is proposed next season to adopt the following distances: 30, 50, 70, 90, and 110 cms.

Thinning.—Here again differences are small, possibly because thinning was done too late.

Plot 36*: Thinning.*	*Yield* (*Kantars per Feddan*).	*P.E.* (*Percentage*).
1 plant per hole, 40 by 80 cms. ..	4·17	2
2 plants „ „ ..	4·12	16
3 plants „ „ ..	4·38	10
4 plants „ „ ..	4·00	7
5 plants „ „ ..	4·34	7

Light resowing.

(*d*) Dates of Sowing and Thinning Cotton.

Plot 37*: Dates of Sowing.*	*Yield* (*Kantars per Feddan*).	*P.E.* (*Percentage*).
July 22	4·10	9
August 7	4·51	11
August 22	4·28	3
September 7	3·63	9
September 22	2·09	3

These results confirm last season's, in that the optimum date comes in the month of August.

This optimum date appears to vary with the season: in light rain seasons it is usually early August; in heavy rain seasons best results are obtained by sowing late in August.

Dates of Thinning (Date of Sowing, August 25).	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Thinning 2 weeks after sowing	3·79	6
„ 3 „ „	4·26	8
„ 4 „ „	3·94	11
„ 5 „ „	3·76	7
„ 6 „ „	3·87	8

Resowing heavy.

(*e*) Manurial Trials, Cotton.

Plot 38: Dates of Application of Sulphate of Ammonia, 200 Rottles per Feddan.	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Control	4·14	4
At sowing	4·60	7
2 weeks later	4·50	3
6 „ „	4·95	6
10 „ „	4·85	8

Resown twice.

Quantities of Sulphate of Ammonia per Feddan (Applied Six Weeks after Sowing).	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Control	4·43	10
200 rottles per feddan	4·60	8
400 „ „	5·48	4½
600 „ „	6·05	4

Resown twice.

Plots 41, 42: Complete Manurial Trials.	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
1. Control	4·45	8
2. F.Y.M.: 3,600 rottles dura stalks, 150 rottles dura grain (fed to sheep)	5·15	13
3. F.Y.M.: +270 rottles of cottonseed added to above ration	4·78	6
4. F.Y.M.: +200 rottles sulphate of ammonia per feddan six weeks after sowing.. ..	5·42	9
5. Complete artificials per feddan: 200 rottles sulphate of ammonia, 300 rottles superphosphate, 150 rottles potash	4·77	10
6. Complete artificials: less nitrogen	4·31	5
7. Complete artificials: less phosphate	5·21	10
8. Complete artificials: less potash	4·88	8
9. 200 rottles sulphate of ammonia: half at sowing, half six weeks later	5·00	11
10. Gypsum: 1 ton per feddan	5·42	8

Resowing in these plots was heavier than in the other Farm plots, with the result that yields are difficult to interpret.

The gypsum was applied on June 15.

Superphosphate was applied on June 27.

Sulphate of ammonia was applied on September 30.

Sheep were on the plots between May 1 and June 30.

Plot 43 : *Methods of Application of Sulphate of Ammonia.*	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Control	5·08	11
200 rottles buried between ridges at sowing	5·61	5
200 rottles broadcast at sowing	5·34	8
200 rottles sown with seed..	5·74	10
200 rottles+200 six weeks later	5·69	7

Results not reliable on account of large amount of resowing.

(*f*) Cultivation Trials, Cotton.

Plots 39 *and* 40 : *Treatment.*	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Shallow rows	4·68	7
Normal rows	5·12	6
Deep rows	4·23	6
Watering two weeks before sowing ..	4·16	10
Watering after sowing	4·24	4
Normal (watering three days before sowing)	4·22	3
Normal	3·87	6
Wide ridges (two drawn together) ..	4·21	3
Sown at the flat (ridges up for the second watering)	4·27	5

Resown.

Plot 9 : *Cultivation Prior to Sowing.*	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Normal cultivation October, 6 inches ..	3·42	2
Deep cultivation October, 10 inches ..	3·44	10
No cultivation: land allowed to crack and ridged up in June	3·67	7

Resown.

From the above experiments it appears that ridging is beneficial purely as a means of water control and distribution in light rain seasons. High ridges in a heavy rain season would have the additional advantage of preventing the plants from becoming swamped. There seems to be a distinct advantage in delaying cultivation until the natural cracking of the soil has taken place.

(*g*) Variety and Strain Tests, Cotton.

Plot 44: Variety Tests.	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Sakel Gezira sown one year at Wad Sulfab from Egypt, 1925	4·57	13
Sakel Domains from Government plant breeder ..	4·57	6
„ B/24 „ „ ..	4·51	10
„ 8 „ „ ..	4·33	8
„ 186 „ „ ..	4·91	5
Assili A/22 G.R.F. seed	4·30	8

Resown.

Plot 45: Strain Tests.	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Sakel seed from Gezira crop 1925-26	3·12	9
„ „ „ „ 1924-25	3·28	10
„ „ „ „ 1923-24	3·01	15
„ „ Tokar „ 1925-26	3·12	7
„ „ Kassala	3·27	15
„ „ Egypt	3·11	15

Poor stand.

Old seed last season was much freer from Blackarm than the new. This season the whole crop was practically free, so differences in the yield are not noticeable.

(*h*) Other Trials.

Plot 43: Cotton Seed Treatment.	*Yield (Kantars per Feddan).*
Control	4·40
Seed delinted with H_2SO_4	4·88

Resown.

Plot 53: Cotton Watering Intervals.	*Yield (Kantars per Feddan).*	*P.E. (Percentage).*
Four days between waterings	2·48	10
Twelve days „	2·44	7
Fifteen days „	2·19	7
Eighteen days „	2·16	6

Resown.

Plot 55: Leguminous Trial Crops.

Beyond Jack Beans, Iron Cowpeas, and Sunn Hemp, which gave a fair return, the following proved a failure:

Soya Beans.	Teel.
Lima Beans.	Earthnuts.
Rose Cocos.	Fasoulis.
Black Beans.	Flax.

(*i*) Manurial Trials, Dura.

Plot 67 : *Quantities of Sulphate of Ammonia per Feddan* (*Applied Two Weeks after Sowing*).	*Yield* (*Rottles : Weight of Heads*).
Control	778
100 rottles per feddan	941
200 „ „	957
300 „ „	1,075
100 rottles at sowing+100 four weeks later	953

Resown.

Plot 68 : *Dates of Application of Sulphate of Ammonia* (200 *Rottles per Feddan*).	*Yield* (*Rottles : Weight of Heads*).
Control	1,196
Two weeks before sowing	1,614
At sowing	1,227
Two weeks after sowing	1,357
Six „ „	1,051

Resown.

(*j*) Dates of Sowing Dura.

Plot 71.	*Yield* (*Rottles : Weight of Heads*).
July 22	1,014
August 7	1,083
August 22	990
September 7	556
September 22	—

Resown.

The latest sowing was entirely eaten by birds.

General Conclusions and Summary.

1. Most of the experiments require the repetition of a number of seasons before definite opinions can be formed.

2. The $\frac{1}{10}$ of a feddan plot has proved a suitable size for all cultural operations, picking and harvesting. It also fits in with the general layout of the 5-feddans plots.

3. Great care has been taken in the picking, harvesting and weighing of the 630 cotton and 403 dura subplots. This will be seen by the comparatively low probable errors, but in spite of this, results in some cases are confusing. This is attributed to resowing. Another season it is hoped to eliminate or very greatly reduce this factor by general adoption of the treatment of cotton seed with sulphuric acid.

4. The high Farm yield is attributed to improved soil fertility plus the effect of sowing nearer the optimum date.

5. On soil similar to the Farm area very little cotton would be lost by cutting out at the end of March in a season like 1926–27.

6. Low temperatures during November and December were thought to be responsible for the almost complete absence of secondary growth.

7. The cotton crop was practically free from pests, except for isolated attacks of Thrips and a slight infestation of Pink Bollworm at the end of the season.

8. Continuous cotton after the ninth crop has yielded, with sulphate of ammonia, 3·41 kantars per feddan, or 1·41 kantars per feddan more than the control, representing a cash profit of £E.3½ per feddan at present prices.

The soil shows no appreciable increase in salts.

9. Optimum date of sowing cotton 1926–27 was about August 7.

10. Optimum date of application of sulphate of ammonia for cotton was sixth week after sowing.

11. Quantities of sulphate of ammonia for cotton: The heaviest dressing, 600 rottles per feddan, gave the highest yield, and was also the most profitable.

12. Quantities of sulphate of ammonia for dura: Heaviest dressing, 300 rottles, gave the highest yield, but was not profitable.

13. Date of application of the sulphate of ammonia for dura: Two weeks before and two weeks after sowing gave the best results.

14. The less striking results obtained with sulphate of ammonia and F.Y.M. this season are thought to be due to the light rain season. Bacterial activity in the soil was never checked. In heavy rain seasons there seems to be a definite check; for this reason much better results are obtained from nitrogenous manuring.

15. Date of sowing dura: August 7 optimum date.

16. Watering intervals for cotton: A nine-days' interval produced a higher yield than did eighteen-days' interval.

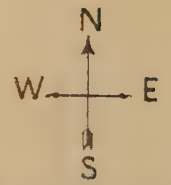
17. A satisfactory leguminous crop has not yet been found to replace lubia.

18. As the Gezira Scheme extends, it is desirable that additional small experimental areas should be started, on which some of the more important trials now being carried out at the Gezira Research Farm could be repeated under the different conditions.

It is suggested that one area in the south (Hag Abdulla extension), one in the west, and one in the north (55,000 feddans area), are required.

Layout G.R.F. 1926-27.

9th Season.



Key
- Cotton.
- Dura.
- Lubia & other crops
- Fallow.

60	59	58	57	56	Rest House 55	Chief Ent. 54	Chief Insp. 53	52	Chem. 51 Chem. Lab.	Ent. 50 Ent. Lab. Ent. Plot	Agric. 49 C.I's Office	Agric. 48 Met. Screen	47	Stores & Cattle 46	Shelter. Native Quarters.
				Dura Obs. Plot	Cotton Obs. Plot	Ent Plot	Watering Intervals	Chemists' Plot.				Manurial Trial	Black Arm Strains	Watering Exp.	
Strains 45	Varieties 44	H_2SO_4 Treatment 43 S. of A. Methods Application	Manurial Trials 42	41	Cultivation Trials 40	39	S. of A. Quantities 38 Dates of Applicn	Dates Thinning 37 Dates Sowing.	Plts. per Hole 36 Spacings	Water and Drying Out 35	300 c.m. 34	350 c.m. Duty 33	400 c.m. Plots Exp. 32	450 c.m. 31	500 c.m.
30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	Module
Three Course Rotations 15	14	13	12	11	10	Cultivation Trial 9	Continuous Cotton 8	Two Course Rot.n 7	6	Continuous Cotton 5	Continuous Cotton 4	Two 3	Course 2	Rotations 1	Module
Varieties 76	Varieties 75	Main Crop 74	73	72	Dates of 71 Sowing	Propagation Plots 70	69	Sulphate of Ammonia 68 Dates Appls	67 Quantities	Water 66 200 c.m.	65 250 c.m.	Duty 64 300 c.m.	Trials 63 350 c.m.	62 400 c.m.	S. of A. Methods 61 Appls

Spill Weir

GEZIRA RESEARCH FARM: PROGRAMME OF EXPERIMENTS, 1927-28

SUMMARY.

		Plots.
1.	Rotations:	
	(*a*) continuous cotton:	
	Tenth season, part manured	4
	Eighth season, no treatment	5
	Second season, no treatment	8
	(*b*) two-course rotations:	
	Tenth season	1–3
	Third season	6–7
	(*c*) three-course rotations:	
	Second season	10–15
2.	Water Duty Trials and Drying-Out Experiment, Cotton	16–20
3.	Thinning and Spacing, Cotton	21
4.	Dates of Thinning and Sowing Cotton	22
5.	Sulphate of Ammonia Quantities and Dates of Application, Cotton	23
6.	Cultivation Trials: H_2SO_4 Treatment	24–25
7.	Manurial Trials, Cotton	26–27
8.	Gypsum Trials, Cotton	28
9.	Variety Trials, Cotton: Plant Breeder	29
10.	Strains Trials, Gezira Sakel	30
11.	Water Duty, Lubia-Dura	31–35
12.	Thinning and Spacing, Dura	36
13.	Dates of Thinning and Sowing Dura	37
14.	Sulphate of Ammonia: Quantities and Dates of Application, Dura	38
15.	Observation and Propagation Plots, Dura	39–40
16.	Feterita-Gassabi-Hemasi Dura	41–43
17.	Varieties Non-Irrigated Dura: Plant Breeder	44
18.	Varieties Irrigated Dura	45
19.	Watering Experiment, Cotton	46
20.	Watering Intervals, Cotton	47
21.	Heavy Manurial Treatment	48
22.	Blackarm Strains and Leguminous Trials Crops	55
23.	Berseem Manurial Trials	56
24.	Cotton Observation Plot	57
25.	Nitrate of Lime: Dates and Quantities	58
26.	Cultivation Trials, Cotton	59
27.	Seed Trials and Methods of Application of Sulphate of Ammonia	60

Areas:	Cotton	137½ feddans.
	Dura	74½ „
	Lubia	20½ „
	Other crops	8 „
		240½ „

Note.—All the cotton seed will be treated with sulphuric acid except for certain check subplots in Plots 24-25, with a view to obtaining a good germination and, as far as possible, avoiding resowing.

As last season, the land will be watered before the sowing of the cotton, and the dura crops: controls will be kept in which the procedure is reversed. The initial flooding will be very heavy for both crops.

Dura sowing will be between August 1 and 15. Cotton sowing will be between August 15 and 30. Observation plots will be sown on the following dates: Cotton, August 20; Dura, August 10.

All the dura seed will be treated with formaldehyde as a precaution against smut.

April 17, 1927.

DETAILS OF EXPERIMENTAL PROGRAMME.

Plot Number.	*Treatment.*	*Number of Subplots.*
1.	Two-Course Rotations (tenth season). Cotton, 2½ feddans, south end. Lubia, 2½ feddans, north end. First Lubia crop cut and fed off on the land. Second Lubia crop cut and fed off after seed taken. *Seed :* main crop.	20
2.	Two-Course Rotations (tenth season). Cotton, 2½ feddans, south end. Fallow, 2½ feddans, north end. *Seed :* main crop.	10
3.	Two-Course Rotations (tenth season). Cotton, 2½ feddans, south end. Dura, 2½ feddans, north end. *Seed :* Cotton, main crop. Dura, main crop.	20
4.	Continuous Cotton (tenth season). *Control :* subplots 1, 2, 6, 8, 9, 10, 11, 12, 13, 20 *F.Y.M. :* subplots 7, 15, 16. *Gypsum :* 1 ton per feddan, 5, 7, 18. *Sulphate of Ammonia :* 400 rottles, 3, 4, 13, 14. F.Y.M. sheepfolded on the land during May. Gypsum applied during June. Sulphate of ammonia, 200 rottles at sowing, 200 six weeks later. *Seed :* main crop.	10 3 3 4
5.	Continuous Cotton (eighth season; no treatment). *Seed :* main crop.	20
6, 7.	Two-Course Rotations. (*a*) Cotton-Fallow. (*b*) Cotton-Dura. (*c*) Cotton-Lubia. (*d*) Cotton-Ads. (*e*) Cotton-Dura, Lubia sown separately. *Seed :* Cotton, main crop. Dura, main crop.	40
8.	Continuous Cotton (second season). *Seed :* main crop.	20

Plot Number.	*Treatment.*	*Number of Subplots.*
10–15.	THREE-COURSE ROTATIONS.	
	1. Cotton. Fallow. Fallow. 2. Cotton. Dura. Fallow. 3. Cotton. Dura. Dura. 4. Cotton. Lubia. Fallow. 5. Cotton. Dura. Lubia.	60
	Seed: Cotton, main crop. Dura, main crop.	
16.	WATER DUTY, COTTON—500 c.ms. per feddan after second watering.	20
17.	Ditto 450 Ditto	20
18.	,, 400 ,,	20
19.	,, 350 ,,	20
20.	,, 300 ,,	20
	Drying-out Experiment: (*a*) No water after March 1. (*b*) No water after March 15. (*c*) Normal, April 15. *Seed:* main crop.	
21.	THINNING AND SPACING TRIALS, COTTON.	
	North end—thinning: (1) One plant per hole. (2) Two plants per hole. (3) Three plants per hole. (4) Four plants per hole. (5) Five plants per hole. Spacing 80 × 50 cms.	25
	South end—spacings: (1) 30 cms. between plants; 80 cms. between ridges. (2) 50 cms. ditto (3) 70 cms. ,, (4) 90 cms. ,, (5) 110 cms. ,,	25
	Seed: main crop.	
22.	DATES OF THINNING AND SOWING COTTON.	
	North end—thinning: (1) Two weeks after sowing. (2) Three ditto (3) Four ,, (4) Five ,, (5) Six ,,	25

Plot Number.	*Treatment.*	*Number of Subplots.*
	South end—sowing : (1) July 22. (2) August 7. (3) August 22. (4) September 7. (5) September 22.	25
	Land to be watered three days before sowing for each date.	
	Seed : main crop.	
23.	QUANTITIES AND DATES OF APPLICATION OF SULPHATE OF AMMONIA, COTTON.	
	North end—quantities : (1) Control. (2) 200 rottles six weeks after sowing between ridges. (3) 400 rottles ditto (4) 600 rottles ,, (5) 400 rottles: 200 at sowing, 200 six weeks later.	25
	South end—dates of application : 200 rottles per feddan. (1) Control. (2) At sowing between ridges. (3) Two weeks later between ridges. (4) Six ditto (5) Ten ,,	25
	Seed : main crop.	
24, 25.	CULTIVATION TRIALS AND OBSERVATION PLOT, COTTON.	
	(1) No ridging up. (2) Two ridgings up. (3) Four ridgings up.	10
	(4) Water before sowing—seed not treated with H_2SO_4. (5) Water before sowing. (6) Water after sowing.	10
	(7) Normal ridges. (8) Two drawn together. (9) No ridges and kept on the flat.	10
	Seed : main crop.	
26, 27.	MANURIAL TRIALS, COTTON.	
	(1) Control. (2) F.Y.M. (3) F.Y.M.+270 rottles of cottonseed fed off.	

Plot Number.	*Treatment.*	*Number of Subplots.*
	(4) F.Y.M.+200 rottles of sulphate of ammonia per feddan.	
	(5) Complete artificials, per feddan: 200 rottles sulphate of ammonia. 300 rottles superphosphate. 150 rottles sulphate of potash.	
	(6) Ditto, less nitrogen.	
	(7) ,, less phosphate.	
	(8) ,, less potash.	
	(9) Sulphate of ammonia, 200 rottles per feddan, two dressings: (1) at sowing, 100 rottles; (2) six weeks later, 100 rottles.	100
	(10) Gypsum, 1 ton per feddan.	
	Gypsum, superphosphate, and sulphate of potash to be applied before sowing. Sulphate of ammonia to be applied six weeks after sowing unless otherwise stated.	
	Seed : main crop.	
28.	GYPSUM TRIAL, COTTON (applied before sowing).	
	(1) 4 tons of gypsum per feddan.	
	(2) 2 tons of gypsum per feddan, and 2 tons 1930.	
	(3) Control.	
	(4) Treatment: 1+200 rottles sulphate of ammonia per feddan.	
	(5) Treatment: 2+200 rottles sulphate of ammonia per feddan.	
	(6) Treatment: 3+200 rottles sulphate of ammonia per feddan.	20
	Seed : main crop.	
29.	VARIETIES (PLANT BREEDER).	
	(1) Sakel Domains.	
	(2) ,, B/24.	
	(3) ,, 8.	
	(4) ,, 186.	
	(5) Murad.	
	(6) Sakel Tokar.	
30.	VARIETIES OF GEZIRA SAKELS.	
31.	LUBIA, 2½ feddans; water duty, 400 c.ms. after second watering.	10
32.	DURA, 2½ feddans; water duty, 350 c.ms. after second watering.	10
33.	DURA, 2½ feddans; water duty, 300 c.ms. after second watering.	10

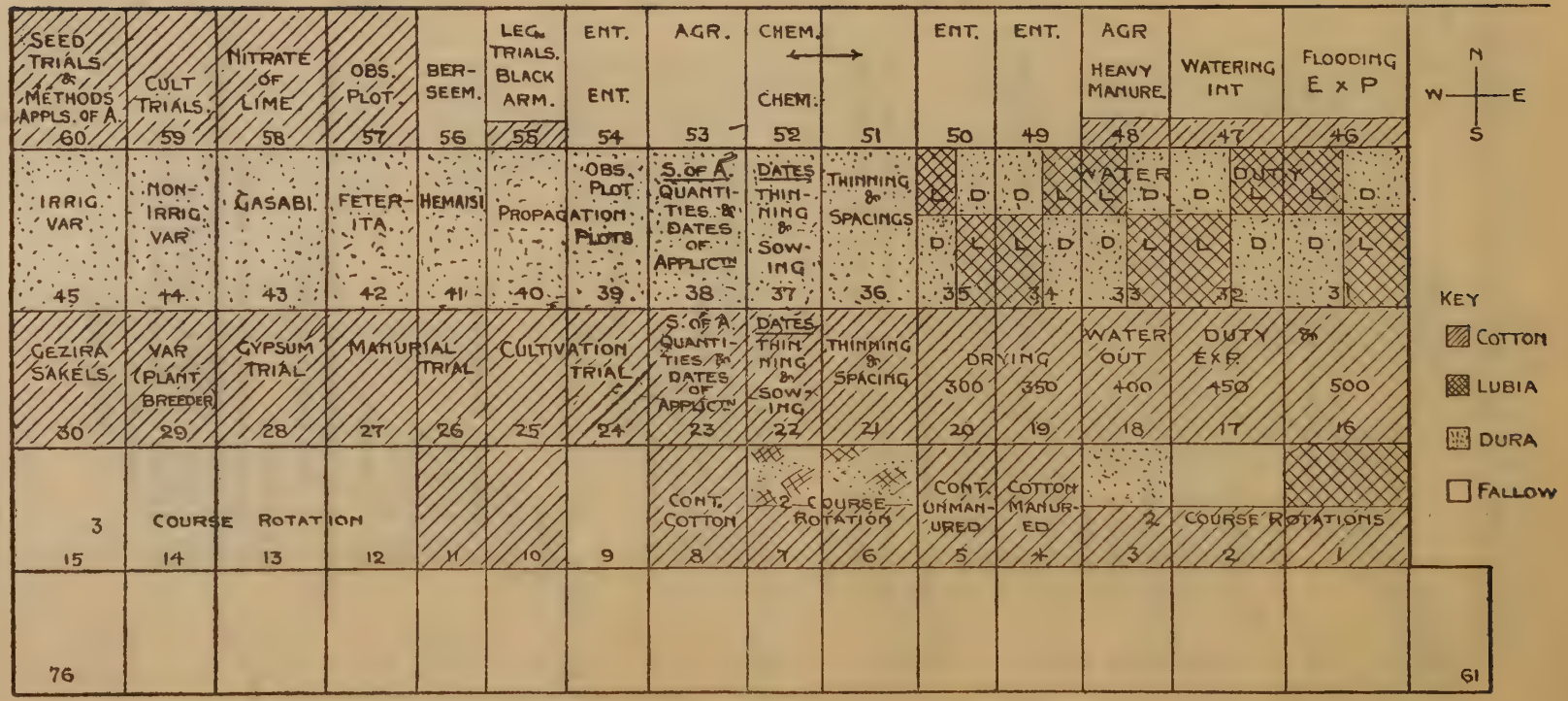
Plot Number.	*Treatment.*	*Number of Subplots.*
34.	DURA, 2½ feddans; water duty, 250 c.ms. after second watering.	10
35.	DURA, 2½ feddans; water duty, 200 c.ms. after second watering.	10
	Gassab+150 rottles grain to be fed off on Plots 62-66. All the lubia crop to be fed off on dura area.	
	Drying-out experiment:	
	Lubia (*a*) December 31.	
	,, (*b*) January 15.	
	,, (*c*) January 31.	
	Seed: Dura main crop.	
36.	THINNING AND SPACINGS, DURA.	
	North end—thinning:	
	(1) One plant per hole three weeks after sowing.	
	(2) Two plants ditto	
	(3) Three plants ,,	
	(4) Four plants ,,	
	(5) Five plants ,,	25
	South end—spacings (two plants per hole)*:*	
	(1) 40 cms. between holes.	
	(2) 60 cms. ditto	
	(3) 80 cms. ,,	
	(4) 100 cms. ,,	
	(5) 120 cms. ,,	25
	Seed: main crop.	
37.	DATES OF THINNING AND SOWING, DURA.	
	North end—dates of thinning:	
	(1) Two weeks after sowing.	
	(2) Three ditto	
	(3) Four ,,	
	(4) Five ,,	
	(5) Six ,,	25
	South end—dates of sowing:	
	(1) July 22.	
	(2) August 7.	
	(3) August 22.	
	(4) September 7.	
	(5) September 22.	25
	Seed: main crop.	

Plot Number.	*Treatment.*	*Number of Subplots.*
38.	QUANTITIES AND DATES OF APPLICATION OF SULPHATE OF AMMONIA, DURA.	
	North end—quantities:	
	(1) Control.	
	(2) 100 rottles per feddan at sowing between ridges.	
	(3) 200 rottles per feddan at sowing between ridges.	
	(4) 500 rottles per feddan at sowing between ridges.	
	(5) 200—100 at sowing, 100 six weeks later.	25
	South end—dates of application (200 rottles per feddan between ridges):	
	(1) Control.	
	(2) Two weeks before sowing.	
	(3) At sowing.	
	(4) Two weeks after sowing.	
	(5) Six ,, ,,	
	Seed: main crop.	
39, 40.	OBSERVATION AND PROPAGATION PLOTS, DURA.	
	Observation plot:	
	(1) Feterita Gezira, main crop	G.R.F.
	(2) Feterita Omda M.S. 37 A.	,,
	(3) Feterita Barakat M.S. 42	,,
	(4) Gassabi Gezira	,,
	(5) Mobaghi M.S. 43.. ..	,,
	(6) Hegari White Nile (selfed)	,,
	(7) Hemasi M.S. 36 A. ..	,,
	(8) Hemasi M.S. 34 A. ..	,,
	(9) Safra (selfed)	,,
	(10) ,, Shendi	,,
	(11) Gassabi Hendi	,,
	(12) Gassabi Egypt	,,
	(13) Gassabi Egypt	,,
	(14) Yellow Jawni India ..	,,
	(15) Khorgi	Shambat.
	(16) Feki Mustahi Kamlin ..	G.R.F.
	(17) Mogid Kordofan ..	,,
	(18) Mugid Kamlin	,,
	(19) Mureig Kordofan ..	,,
	(20) N. Dura	,,
	(21) Aklamoya Kassala ..	,,
	(22) Shelshala M.S. 44 ..	,,

Plot Number.	*Treatment.*	*Number of Subplots.*
	Propagation plot:	
	(1) Feterita, 1931, 4A/27.	
	(2) „ „ 4B/27.	
	(3) „ „ 5/27.	
	(4) „ „ 3/27.	
	(5) „ „ 3A/27.	
	(6) „ Omda, 39/27.	
	(7) „ Omda, 37A/27.	
	(8) „ Barakat, 4/27.	
	(9) Safra selected.	
	(10) Hemasi, 34/27.	
	(11) Gassabi, 45/27.	
	(12) Hemasi, 38/27.	
	(13) Egyptian Dura, Gadi.	
	(14) Egyptian Dura, Safra.	
	(15) Kassala Dura, Toleeb.	
	(16) Kassala Dura, Aklamoya.	40
41.	Hamasi: main crop.	60
42.	Feterita.	
43.	Gassabi.	
44.	NON-IRRIGATED VARIETY PLOT, DURA.	
	(1) Feterita, 1931 SS. .. G.R.F.	
	(2) Feterita, 1931 SS. .. Shambat.	
	(3) Main crop.	
	(4) Feterita Omda .. .. G.R.F.	
	(5) Feterita 3232 .. ... Shambat.	32
45.	IRRIGATED VARIETY PLOT, DURA.	
	(1) Safra.	
	(2) Hemasi.	
	(3) Feterita, 1931, SS.	
	(4) Main crop.	
	(5) Gassabi.	20
46.	WATERING EXPERIMENT, COTTON.	
	(*a*) Heavy watering on April 15.	
	(*b*) Control: no water.	
	Seed: main crop.	
47.	WATERING INTERVALS EXPERIMENT, COTTON.	
	$7\frac{1}{2}$ days.	
	10 „	
	15 „	20
	Seed: main crop.	

Plot Number.	*Treatment.*	*Number of Subplots.*
48.	HEAVY MANURIAL TREATMENT (1 feddan, cotton).	
	(1) Control.	
	(2) 1,120 rottles dura per feddan, 540 rottles cottonseed, 3,600 gasab, fed to sheep.	8
	Seed : main crop.	
50.	ENTOMOLOGICAL SECTION.	
52.	CHEMICAL SECTION.	
54.	ENTOMOLOGICAL SECTION.	
55.	BLACKARM STRAINS AND LEGUMINOUS TRIAL CROPS.	6
56.	BERSEEM MANURIAL TRIAL (4 feddans).	
	(1) Sulphate of ammonia, 200 rottles per feddan.	
	(2) Gypsum, 1 ton per feddan.	16
	(3) Control.	16
57.	COTTON OBSERVATION PLOT.	20
58.	NITRATE OF LIME: QUANTITIES AND DATES OF APPLICATION (cotton treatment as Plot 23 and layout).	50
	Seed : main crop.	
59.	CULTIVATION TRIAL, COTTON.	
	(1) No cultivation; ridged up only.	
	(2) Cultivated October.	
	(3) Cross October.	
	(4) Subsoiled May.	20
	Seed : main crop.	
60.	SEED AND SULPHATE OF AMMONIA TRIALS (cotton).	
	Seed trials :	
	(1) 1926–27, Gezira seed.	
	(2) 1925–26 ,,	
	(3) 1924–25 ,,	
	(4) 1923–24 ,,	
	(5) Tokar seed.	25
	Methods of Application of Sulphate of Ammonia (200 rottles per feddan).	
	(1) Control.	
	(2) Applied between ridges at sowing.	
	(3) Applied buried between ridges at sowing.	
	(4) Applied on top of ridges buried.	
	(5) Applied on top of ridges +200 six weeks later buried.	25
	Seed : main crop.	

G.R.F. Layout. 1927-28



GEZIRA RESEARCH FARM BOTANICAL SECTION: ANNUAL REPORT, SEASON 1926-27

BY

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INTRODUCTION.

Arrangement of Subjects.—The arrangement of the subjects discussed in this Report is as follows:

Part I.—Review and Summary of the more detailed treatment in Parts II. and III., with conclusions.

Part II.—Some general notes on plots, and notes on factors of importance in plant development.

Part III.—The results of observations and tests. Notes are attached to the diagrams explaining and discussing these.

Tabulated figures are given in the Appendix.

General.—The work is carried on under the general supervision of the Government Botanist and the Plant Breeder.

In addition, the Farm supervision has been undertaken for four months during the sowing period and after. This period coincided with the introduction of the new system of layout of the Farm Experiments, and therefore no time was available for botanical work till November. Much of the most important period of development was thus unfortunately missed.

With the botanical work as a whole-time duty in the future it will be possible to extend the work, and ensure greater accuracy in results. Past data require further analysis, time for which has not been available in the past.

Accommodation.—The new offices were not available till near the end of the year.

PART I.—SUMMARIES AND CONCLUSIONS.

Summaries of Subjects Discussed in Parts II. and III.

Note.—All the tests are carried out on cotton from two series: (1) Observation Plot; (2) Date of Sowing Plot.

1. *Flower Curves and Relation of Meteorological Conditions and Irrigation to Flowering.* (See Figs. 1 and 2 and note to Figs. 1 and 2.)

Various investigations have shown that flower-bud shedding may be produced by conditions of water-strain in the plant.

During the period September to November meteorological conditions occur that are likely to produce water-strain.

Meteorological curves have been charted so that the relations of the curves to these conditions twenty-two days previously are shown. On making this comparison in the observations from the Dates of Sowing Plot a sharp fall of the flower curves is seen to coincide with meteorological conditions likely to produce excessive water-strain. Other coincidences of the same character are observable at other dates, for which a rather greater shift would produce the best fit.

Similar effects are seen in the Observation Plot Curve. In this case a longer shift gives a rather better fit.

The smoothness of the curves in the early period indicates low bud-shedding previously.

The Flower-Curves of mid-August and later sowings start at eight to nine weeks after sowing, compared with about eleven weeks for the July sowing.

Conclusions.—There are strong indications of excessive flower-bud shedding in October produced by stringent meteorological conditions. Flower-bud shedding in the early period (September) was low. This may be in part the result of more frequent irrigations in the early period.

The period before flower production began was about two weeks longer for early sowings than for later sowings.

2. *Boll Curves—Frequencies.* (See Figs. 4 and 5 and note to Figs. 4 and 5.)

A very large number of bolls are shown to have matured at the beginning of January, particularly from the July 22 sowing. This was due to a tendency to shortening of the maturation period for flowers opening at the end of October.

Another period of quicker maturation occurred in the second week of February.

The relative amounts of pickings in these periods depend on the spacing of plants and dates of sowings. With wider spacing and later sowing very heavy pickings would occur in the later period, and comparatively less in the earlier one.

3. *Maturation Period and Proportions of Diseased and Subnormal Bolls.* (See Fig. 3 and note).

Maturation Period. The dates of flower opening and the corresponding dates of bolls from these through the season are shown in the diagram (Fig. 3).

Some variations from the figures given may occur with other dates of sowings, other strains of seed, and with varying proportions of healthy and diseased bolls.

In this case the greatest variation is likely to be due to the latter cause.

Percentage of Healthy and Diseased or Subnormal Bolls.—The percentages of these through the season are shown. A high percentage of the latter is shown to have occurred in the latter part of the season.

This plot was affected by Blackarm. The proportions of poorer quality bolls are likely to be greater than in most of the Farm cotton.

Shedding was not excessive.

Relation of Maturation Period to Temperatures.—Indications are noted of a relationship between the temperatures and the maturation period for temperatures about twenty days after flowering.

4. *Cumulative Numbers and Weights of Bolls. Cumulative Numbers of Flowers.* (See Figs. 6 and 7 and note to Figs. 6 and 7.)

Numbers of Bolls.—Considerable differences are shown, the July 22 and August 7 sowings having much higher figures than the remainder. Lesser differences are shown between the others.

Weights of Bolls.—Very considerable differences are shown.

The August 22 sowing had much heavier bolls than the two earlier dates. The comparative figures do not agree with the Farm yield figures, but these differences may be explained by plot sampling errors, and by losses of fallen cotton between the earlier pickings.

The Observation Plot bolls show a rather low weight per boll.

Observations on numbers of bolls should always be supplemented by boll weights.

Numbers of Flowers.—On the Observation Plot the calculated shedding percentage was 35·4.

The calculated shedding percentages on the Dates of Sowing Plots are very low, except for the September 22 sowing. These figures are subject to considerable errors and are not given.

Conclusions.—The low shedding percentages of flowers and bolls suggest that this is an important factor in producing the high yield this season.

5. *Lint Length and other Data relating thereto.* (See Fig. 5 and note, and Appendix I.)

Lint-length measurements of the Dates of Sowing Series, and of the means of single-dated bolls of healthy cotton from the Observation Plot, are charted to show variation through the season.

Temperatures occurring forty-five days previously are charted to show the relationship of these to lint length.

Irrigations are advanced in the chart by the same period. These are related to the lint character by their effect on water supply and soil temperature.

The dates at which two-thirds of the crop for each series has matured are shown as an indication of the lint length of the bulk of the crop.

Conclusions. — (1) Two factors appear to influence length. (*a*) Meteorological conditions. There appears to be a tendency for low temperatures to produce shorter lint. (*b*) Age of the plant. In the earlier stages of boll production length appears to be greater, getting less as the period advances.

(2) The effect of the date of sowing on variation in lint length is important in connection with the present movement towards a later date of sowing, and should be investigated fully.

6. *Ginning Outturn and its Relation to Lint Length, Lint Weight, and Seed Weight.* (See Fig. 9 and note, and Appendix II.)

Ginning Outturns for the mean of all Gezira cotton and for Barakat cotton are charted, in addition to those for the Farm crops.

Comparisons of Ginning Outturn show that the Farm figures are higher than the Gezira figures for the earlier dates of picking. This difference may be due to loss of weight of the seed from storing in small lots.

From the general agreement of the Ginning Outturn curves for the Gezira as a whole with the Farm crops curves, it is inferred that the changes in the components that affect the outturn are of the same general trend in each case.

Conclusions.—(1) There is a marked tendency to a high Ginning Outturn from the latter part of January through February. This is associated with considerably lighter seed.

(2) The higher Ginning Outturn of the August 22 sowing in the period January to February is associated with markedly shorter lint, but with a rise in lint weight. It appears to indicate considerable thickening of lint hairs, which means stiffer, coarser lint.

(3) The lint weight for both series by comparison with the length appears to indicate a tendency towards a general thickening of lint hair coinciding with a fall in lint length, from the latter part of January onwards except for the latter end of season.

(4) Examinations of hair weight per cm. are necessary before definite conclusions can be come to as to the amount of hair thickening.

7. *Meteorological Conditions.*

These are a determining factor in the whole course of the plant's development. Their relations to different stages of this development are discussed under these headings.

8. *Soil Conditions.*

(*a*) Nitrogen Supply (see Section 2, Part II., and Appendix III.). —Figures for nitrates in the Dates of Application of Sulphate of Ammonia experiment are given for the period August to December. The same trend is shown in manured and in unmanured plots, the highest point being reached in November.

Not much difference is shown between the two series till November, and by comparison with yields, it is concluded that the nitrate content in the earlier months is of the most importance, and that sufficient was available in unmanured soil to produce a good crop.

The applications of manure appear to have influenced the yield most by their effect on nitrate content later.

Conclusions.—With a more accurate knowledge of the conditions governing nitrate formation, the optimum date of application of fertiliser under different seasonal conditions could be determined more accurately, and applications made at that date.

(*b*) Water Movement.—Investigations by Dr. Greene have shown that irrigation water can be made to penetrate much deeper than it normally does. This may be in particular beneficial under the conditions of water-strain discussed in regard to the flower curves. An experiment will be carried out next season to test this in connection with irrigations at varying intervals.

(*c*) Temperatures.—These probably have an important influence, but very few data are available. They are markedly affected by irrigations.

9. *Irrigation.* (See Section 3, Part II.)

The possible effect of the greater number of irrigations given this season in the early period is referred to. This factor may be in part responsible for the low flower-bud shedding shown in the early part of the flower curve.

Irrigations affect conditions of water-strain in plants, nitrate development, and soil temperatures.

10. *Spacing.* (See Section 4, Part II., and Appendix IV.)

Variations in spacing affect the length of the period of picking, closer spaced plants giving their maximum number of bolls in a shorter period than those more widely spaced.

The quality of the cotton may be also affected. The rather low quality of the Farm cotton this year may be in part due to the rather closer spacing employed.

The length of the period of picking has a bearing on labour supply and on the date of cessation of irrigation.

11. *Seed Origin.* (See Section 6, Part II.)

Negative results were obtained in comparison of strains. The Tokar seed was vigorous and healthy.

12. *Blackarm.* (See Section 5, Part II.)

Hot, dry conditions at the sowing period coincided with an apparently complete absence of Blackarm in the Farm crop (except on self-sown cotton) for some time after sowing.

Some development occurred later following rain conditions and low temperatures. The relative infection of seed of different origin was not brought out clearly.

Results tend to indicate that Shambat seed is liable to develop Blackarm rather readily.

General Summary and Conclusion.

High Yield.—The influence of two main factors was probably decisive:

(1) There appears to have been sufficient nitrates in the soil—indicated by the high yields and comparison of the nitrogen contents of manured and unmanured plots.

(2) The comparatively slight damage from Blackarm. The Farm cotton was very slightly infected; many Gezira areas were infected more, but recovered well.

The first factor has been associated with a low rainfall, and the second also generally with drier, hotter conditions than usual during and after the sowing period.

Sequence of Causes.—The following explanation of the sequence of causes is advanced:

Low rainfall followed by high nitrates in the soil.

Comparatively dry, hot conditions during and after sowing followed by little Blackarm infection.

Little Blackarm infection and high nitrates followed by little leaf-shedding and vigorous growth.

Low bud-shedding due to little leaf-shedding and vigorous growth.

High flower production from October till early November due to low bud-shedding and healthy growth.

Low flower and boll shedding due to little Blackarm infection and healthy growth.

Enough flowers were apparently produced in the earlier period to produce the good crop, in spite of the sharp drop in the flower curve in early November.

The heavy early pickings were due to the heavy early flower production, associated with low shedding and quicker maturation.*

The effect of cattle manuring of the Farm, and vigorous, healthy seed, and irrigation before sowing, may all be expected to have had a beneficial effect, but the high yields throughout the Gezira show that there were other decisive factors common to all areas.

Quality of Cotton.—As there is very little information for other years, only general conclusions can be reached.

Cotton from the main sowings (July and August) showed a distinct trend towards shorter lint for that maturing from the latter part of January onwards. From the latter part of February the lint was very short.

Associated with the above changes, there appears to have been a tendency towards coarser lint.

The quality of all the later cotton (from the end of February) was distinctly poor.

In later-sown cotton there is a different sequence. Distinct differences in character are shown between that sown on August 22 and earlier sowings, and these should be investigated fully.

PART II.—1. PLOT NOTES.

(1) Cotton.

Variety Trials (*Plot* 44).—The results of these are dealt with fully in Mr. Bailey's report. (See p. 143.)

Observation Plot (*Plot* 55).—This is reserved especially for detailed observational work. The more detailed plant development records were made on this plot.

* The above applies particularly to the Farm cotton. It will hold good for the Gezira generally, but owing to the wider spacing and average better soil (as shown by the average seasonal yields), flowering would tend to be continued later, with a rather higher proportion of the crop from later periods.

Date of Sowing Plot (*Plot* 37).—Plant development records were made on this plot also. Cotton from the Observation and Date of Sowing Plots was used for the tests, the results of which are examined in Part III.

(2) Dura.

Variety Trials.—The results of the trials were inconclusive in some respects. In the non-irrigated trials a Beladi *Feterita* was found to have an exceptionally early-maturing character, but was of rather weak habit.

Observation Plot.—Owing to severe losses from Chafer Grub a number of resowings were necessitated, and it was difficult to make comparisons. Some elimination was carried out, and other varieties were reserved for trial in the following season.

Selection Work.—A large number of selections were made of possible strains and varieties. Of these the bulk will be rejected in the following season, keeping the best only.

2. FACTORS AFFECTING PLANT DEVELOPMENT.

(1) Meteorological Conditions.

These are of great importance. Their effects are discussed under other headings.

(2) Soil Conditions.

(*a*) *Nitrogen Supply* (see Appendix III.).—The relation between nitrogen supply and the crop's development is of great importance, but very complex. The bearing of Dr. Crowther's figures* for the relationship of rainfall and yield for the present season has not been examined fully, and no comments can be made on these.

Figures of nitrate content (of the first foot of soil) for this year's cotton crop are available for the Continuous Cotton Plot and for the Dates of Application of Sulphate of Ammonia Plot from August to December, and these were kindly supplied by Dr. Greene. The figures show great variation. All plots showed the same monthly trend, the amount of nitrate (parts per million) increasing to a peak in November, and sinking more rapidly in December.

An outstanding feature is the markedly greater increase in nitrate of all manured plots from October to November. The persistent high nitrate figure for earlier manured plots is also noticeable except in the case of the late application.

* Dr. Crowther observed a close inverse relationship between the yield of cotton and the amount of rainfall in May and June. He put forward the hypothesis that heavy early rains depress the yield of cotton by reducing the available nitrate supply during the period of active plant growth. It has not been possible to examine these questions during the past season.

Comparing the nitrate figures for the different months with the yields, it appears probable that it is the nitrate content in the earlier periods which was of chief importance in influencing yield. The very much higher nitrate figures of manured plots for November and December are not associated with a proportional increase in yield.

If the yield for the last application be taken as significant, the rather higher yields of the manured plots as a whole are due to their higher nitrates in the later periods—*i.e.*, owing to a comparatively high nitrate content in the unmanured plots from August to October; little differential effect was actually produced by the earlier applications, the effect being caused by the amounts of nitrate shown to be present in November and December.

(*b*) *Water Movement.*—This is necessarily of the greatest importance in relation to plant development.

The investigations by Dr. Greene on the penetration and movement of water in the soil have a close bearing in particular on the conditions affecting flower-bud shedding which are discussed in the Note to Figs. 1 and 2. These investigations have shown that it is possible to get water down to a much greater depth than is reached by ordinary irrigations, by means of very heavy flooding before sowing, and by the use of gypsum. If a deeper root system can be developed than that commonly found, which is apparently usually only shallow, the bad effects of water-strain in the plant under high evaporation conditions may be largely prevented.

An experiment to test the effect on bud-shedding of heavy flooding before sowing, and to compare this with that of the ordinary flooding, and with shorter interval irrigations, is being carried out jointly with the Chemical Section in the 1927–28 season.

(*c*) *Temperatures.*—This is probably of great importance, but few data are available yet.

Temperatures have been taken by a self-recording thermograph in the Observation Plot from November onwards. Owing to variation in the instrument, however, producing a possible error in the absolute figures, no particulars are given here. A marked effect of irrigations on soil temperatures is shown—a change of up to 8° to 9° C. occurring at 12 cms. depth two days after irrigation, when the latter coincided with a fall of air temperatures.

(3) Irrigation.

Owing to the dry conditions, irrigations and cultivations began earlier and were at closer intervals during the first two months after sowing. These may have had an influence in promoting the early

development of flowering branches that occurred generally. The abnormally low flower-bud shedding indicated by the earlier parts of the flower curves may also be partly the result of these conditions.

Soil temperatures, water-strain of the plants, and nitrate development, are all influenced by irrigation.

(4) Spacing. (See Appendix IV.)

This must be regarded from other aspects than that of the comparative final weight. It tends to affect the length of the picking period, and may affect the quality of the cotton. In the present season not much difference is noticeable in the former aspect in the Spacing Experiment results. It is shown very clearly, however, in some figures given in Appendix IV., which are taken from experiments carried out in Egypt.

In regard to the quality of the cotton we have no data as to this effect here. Later cotton (which would be produced by wider spacing) is probably more affected by lower temperature. It is noted by Balls,* however, that closer-spaced cotton is more liable to be affected by hot and dry conditions.

It is possible that the fact that the Farm cotton was rather below average quality, as shown by the report of the sale, is partly due to the latter effect—the Farm cotton being planted at a closer spacing than the Gezira cotton.

The length of the picking period may be of considerable importance in connection with a possible labour shortage in the Gezira. It also has a bearing on the effect of the date of cessation of irrigation. In the case of a very early cutting off of the water, a closer spacing could be employed.

(5) Blackarm.

The crop as a whole was exceptionally free from Blackarm. This applies not only to the main sowings, which took place between August 15 and 25, but also to the Dates of Sowing Plot, with a wide range of dates.

Relation between Blackarm Incidence and Rainfall.—The main crop sowings had entirely dry conditions from the sowing date till September 1, when there was a fall of 17·5 mm., very local, on the south part of Farm only, and 13·2 mm. on September 2 on the north end.

The July 22 sowings had light falls on four days during July, and a heavy fall (52·2 mm.) on August 1. The only other fall of any

* "Analyses of Agricultural Yield": Part I., Spacing Experiment with Egyptian Cotton 1912. W. L. Balls and F. S. Holton.

appreciable amount during the whole sowing period occurred on August 18 (32·2 mm.)

Both the July 22 sowing and the August 7 sowing had either light falls or none at all for nine and six days respectively after sowing, and in each case dry conditions followed the heavier rainfall.

During the whole of the latter part of August exceptionally hot and dry conditions were experienced.

The only Blackarm noticed in this period was on self-sown cotton or fallow, and on cotton in the Continuous Cotton Plot (also self-sown).

Light infection was apparent on all Farm plots in the latter part of September, although usually only observable by close inspection. Falls of rain occurred at the beginning and middle of the month. In all cases infection was first noticed on Abu Sitta banks. Examination through all the Farm plots showed, however, that there was no significant difference in the number of plants affected either near the water inlet, in the middle of the plot, or at the side furthest from the water inlet. Infection was, however, in all cases more severe in the two to three rows nearest the water. This may be explained by the lower soil temperatures under these conditions.

Certain plots were more affected than others—viz., Continuous Cotton, Variety Trials, and Observation Plot, and to a lesser degree the short-period Rotations. The Variety and Observation Plots were Shambat seed, the former untreated with sulphuric acid, the latter treated. The July 22 and August 7 sowings were a little more infected than the bulk of the Farm cotton.

No development occurred in October, but fresh lesions appeared in mid-November; this followed showery weather and lower temperature.

No differential infection was shown in the seed treated with sulphuric acid and the untreated seed (Egyptian), and in that used for the Strains Trial (Plot 4), none of which was more infected than the remainder of the Farm seed.

(6) Seed.

In the present season practically very little difference was observable, if any, in the Strains Plot (Plot 45) between plots of seed of different origin. Egyptian Sakel was possibly a little less vigorous than the others. The Tokar seed sown was vigorous and healthy.

PART III.—OBSERVATIONS AND TESTS.

1. Flower and Height Curves. (Note to Figs. 1 and 2.)

Selection of Plants and Observations.

Observation Plot: *Selection of Plants.*—Two hundred plants were observed. The number is sufficient to give a low sampling error.

Observations: Flowers.—Made daily, except for two to three days after irrigations, when they were omitted. The number of flowers produced on these days was estimated by averages of the preceding and succeeding days.

Height.—Made every ten days.

Date of Sowing Plot.—Twenty plants were observed on each subplot, and 100 plants from each date of sowing. The error of sampling is therefore greater than in the Observation Plot, but sufficiently accurate for general comparisons between the treatments.

Observations: Flowers.—Made for three consecutive days and omitted for two days following. The observations, however, are sufficient to give the general form of the curves.

Height.—Every ten days.

Meteorological Charts.

Flower-Bud Shedding and Water-Strain.—An attempt has been made to correlate the incidence of meteorological conditions with the number of flowers produced from the effect of the former on flower-bud development.

A considerable amount of data has been accumulated by various investigations on flower-bud shedding and the factors affecting this. It is generally recognized that conditions producing water-strain in cotton plants, while flower-bud development is taking place, tend to produce shedding, which may be severe under stringent conditions. The subject has been examined very fully by Bailey* in Egypt. His conclusions were that bud-shedding was of great importance in determining flower production, and hence the crops harvested. Buds of a very small size were shed to a much greater extent than larger ones—*i.e.*, the maximum effect on the flower curve was produced about thirty days after adverse conditions occurred resulting in shedding.

Gezira Conditions.—In the Gezira there occurs each season during the period September to November a marked fall of humidity, a rise in evaporation, and higher temperatures. There is usually also one period when these conditions are very marked, associated with strong dry winds. In the 1926–27 season this occurred between October 18 to 25, a very marked fall in humidity and rise in evaporation occurring, with high temperatures during part of the period and a strong wind. Wilting was observed during this period on many

* "Growth, Bud-Shedding and Flower Production in Egyptian Cotton." M. A. Bailey, Bulletin No. 65, Ministry of Agriculture, Egypt.

plots previous to irrigation. The wilting, however, was not so marked in the Observation Plot as in some others.

To determine the effect on flowering of previous adverse meteorological conditions likely to produce bud-shedding, the Meteorological Curves have been moved forward on the diagram, in this case twenty-two days, and charted on dates coincident with the flower curves of twenty-two days later. If bud-shedding occurs at this earlier period it will be shown by a fall in the flower curve at the later date, and the relation to meteorological conditions at the early period will be shown.

Dates of Sowing Plot.—In the Dates of Sowing Plot the outstanding feature of the flower curve is the very sharp drop shown with the four earlier dates of sowing, and a small drop seven to nine days later with the last date of sowing. If, as seems extremely probable, the drop is the result of the adverse condition about twenty-two days earlier, this means that older buds (than found by Bailey) were shed in excessively large numbers. The stringent conditions would account for this. The lowness of the curve for the September 7 sowing for eighteen days after the first rainfall occurred would be accounted for by the shedding of both larger and smaller squares, following these conditions, with a second shedding wave produced by the stringent conditions occurring fifteen days after the previous one.

There is some uncertainty as to the shape of the curves on the days when observations were omitted, and a slightly different shift might give the best true fit, but with this reservation the remarks above hold good.

Other coincidences are observable in the latter periods, but not so markedly as in the previous case.

The effect of very low temperatures is uncertain. They may be expected to produce some shedding, but data on this are scanty. The drop in the flower curve for the September 22 sowing on December 11, and again on January 1, would give a good fit for this with a thirty days' shift.

Observation Plot.—In the case of the Observation Plot, the small rise occurring on November 17 may be accounted for by the supposition that older squares were less affected in this case, probably due to the previous irrigation having been heavier than on the Date of Sowing Plot. The lowness of the curve on November 14 might be due primarily to slight shedding occurring before the irrigation of September 12—charted against November 12 (on a thirty-two days' shift)—with a tendency to rise again following the irrigation. The effect of the adverse conditions (charted against November 14) would be to accentuate the drop in the flower curve, but shedding might not be severe enough to check completely the rise that was tending to occur just after this, due to irrigation thirty-two days earlier. The main effect in this case is shown in the fall following the slight rise, and this would therefore coincide better with a longer shift.

2. Maturation Period and Proportions of Diseased or Subnormal Bolls. (Note to Fig. 3.)

Seed: Massey's Domains Sakel.

Maturation Period.—The corresponding dates for flowers and bolls at any period are shown by the intersection of the ordinates for dates of flowers and bolls.

The straight line for a maturation period of sixty days, by comparison with the actual maturation curves, shows the general trend of these.

No maturation figures for other plots, other dates of sowing, or from seed of other places of origin have been obtained. While there is likely to be some variation, not much difference is to be expected generally in this respect in absolute figures.

The biggest difference is likely to be caused by variations in proportions of healthy and diseased or subnormal cotton. There are differences in this respect, as is shown by a comparison of Figs. 6 and 7, and the possibility of such differences must be allowed for in using the maturation periods charted.

Percentage of Healthy and Diseased and Abnormal Bolls.—The classification was done by the writer daily into three classes, Good, Medium, and Poor, the "Medium" and "Poor" cotton coming under the heading of Diseased or Subnormal Bolls.

The plot from which these bolls were taken was distinctly more infected with Blackarm than the great majority of other plots, and this may be due to its place of origin—Shambat, as compared with Tokar, from which the seed for the main crop, including the Dates of Sowing Plot, was obtained.

There is therefore probably a larger proportion of diseased and subnormal seed cotton from this plot than in other Farm crops. The very poor quality of the latter part of the crop is shown.

Shedding of flowers and bolls was not excessive.

A possibility of error is introduced by the effect on the bolls of the attachment of labels. This may be expected to tend to increase shedding, and possibly to affect the quality of the cotton somewhat. No comparative figures, however, are available to check this, but nevertheless the general trend of the changes taking place should be indicated accurately by the curve.

Maturation Period and Relation to Meteorological Conditions.—A feature of interest in regard to the variation in the maturation period through the season may be noted.

If the maturation periods of bolls be charted as a frequency curve of the number of days taken to mature against the dates of flowering of the bolls, and the temperatures during the same periods be charted on the same date scale, but with the latter shifted forward about twenty days, some agreement in the general shape of the curves in an inverse direction is observable, a fall in temperature tending to coincide with a lengthening of the maturation period, and *vice versa*. This is observable in both the 1925–26 and 1926–27 curves.

3. Boll Curves. (Note to Figs. 4 and 5.)

The diagrams representing the boll production from the same series are dealt with in Figs. 1 and 2.

Dates of Sowing Plot.—The remarkable peak in the curve for the July 22 sowing, and the lesser peaks in the August 7 and 22 sowings, are quite abnormal.

They are clearly due to a shortening of the maturation period with a high rate of flowering previously, a phenomenon which seldom appears to occur in the Gezira, the period usually steadily lengthening for the flowers opening through October and November, when the bulk of these are produced. It is very easily seen by reference to Fig. 2 that if a shortening of the maturation period occurs for the bolls from flowers opening near the peak of the flower curve, so that, say, the rate is such that three days' flowering results in two days' bolling, a very heavy flush of bolls will result.

A tendency to a shortening of the period is shown in the maturation diagram for flowers opened near the end of October (opening as bolls at the end of December).

The figures appearing as the peaks in these cases are averages from six-day pickings. There is, then, a close agreement with the diagram.

A similar effect (from shortening the maturation period), though not so marked as in the previous case, is shown in the September 7 sowing for bolls opening in the second week of February. Reference to the diagram shows that the flowers between December 1 and 14 opened as bolls from February 7 to 12—*i.e.*, the flower production of twelve days was crowded into five days.

With wider spacing conditions, as in the Gezira, producing longer periods of development, and where sowing was late, this effect would be very marked.

Observation Plot.—The same effects, due to variations in maturation periods, are shown as in the Dates of Sowing Plot, although not so markedly.

A general relationship between variations in the maturation period and temperature variation is referred to in Note to Fig. 3.

4. Cumulative Numbers and Weights of Bolls. Cumulative Numbers of Flowers. (Note to Figs. 6 and 7.)

The data for these are from the same series as those for Figs. 4 and 5.

Numbers of Bolls.—The figures are for all bolls opened, healthy or diseased. The order of superiority follows the date of sowing. A very considerable difference is shown between the two earliest dates of sowings and the third. The other dates of sowing show less comparative differences.

Weights of Bolls.

Dates of Sowing Plot.—A comparison of Figs. 6 and 7 shows considerable differences. The August 22 sowing has a marked superiority

in weight per boll, although not sufficient to counterbalance the larger number of bolls produced by the first two Dates of Sowing. This is confirmed by the weights of seed cotton shown in Fig. 9. The September 22 sowing shows a low weight per boll. This is probably largely due to a severe Asal attack. The differences between the results for the first three dates of sowing, however, are not sufficient to be considered significant. There is actually a conflict of results between these figures and the returns for the Farm yields. While plot-sampling errors would probably be sufficient to account for this, a part or the whole of the differences may be accounted for by losses from fallen cotton.

In the July 22 sowing particularly there was an interval of twenty-two days between the beginning of the opening of the bolls and the first picking, and nineteen days between the first and second pickings. There was a large boll production during the period, principally between the first and second pickings, associated with strong winds, and it may be inferred that some losses occurred then.

Observation Plot.—A considerable difference is shown in the weights per boll for this plot compared with the August 22 sowing in the Date of Sowing Plot—the most comparable of the series, the Observation Plot being sown on August 19. It is indicative of the presence of more diseased and subnormal bolls, as is mentioned in the Note to Fig. 3.

It is evident that comparisons of numbers of bolls must always be supplemented by figures for their weights.

Numbers of Flowers.

There is an element of error in this, owing to the lack of figures for days when observations were omitted. These figures were estimated by averaging the number of flowers on days preceding and succeeding the days when observations were not made.

The results will express the general form of the curve fairly accurately.

Shedding Percentage.

Observation Plot.—The actual shedding percentage of the number of flowers, calculated from the figures for flowers and bolls (the latter up to April 30), is 35·5 per cent.

Date of Sowing Plot.—In the Dates of Sowing Plot the shedding percentages calculated are all very low for the first four dates of sowing, and considerably higher for the last date of sowing. There is, however, a considerable possibility of error in these figures, owing to the greater number of days on which flower observations were omitted.

5. Lint Length. (Note to Fig. 8.)

Two series of results are dealt with:

1. Date of Sowing Plot.
2. Observation Plot.

1. *Date of Sowing Plot.*—The samples examined were from the seed cotton picked from the observation plants from which the curves for flowering and bolling were obtained, and are thus from the same plants throughout.

Cotton of very poor quality was kept separate in picking, and samples were drawn from the remainder.

Three-day pickings were made. Pickings for six days were sampled, except where insufficient cotton was available, as at the end of the season, when longer periods were taken. Each lot was mixed thoroughly, and twenty-five sub-basal seeds selected at random from healthy locks. These were combed out to a semicircular halo and measured. The means of these figures are charted.

2. *Observation Plot.*—These measurements were made on single bolls of the series used for the maturation period estimations. The healthy bolls from forty plants out of the 200 used were selected for estimations of lint length and other characters. The three sub-basal seeds for each boll were measured by the semi-circular halo method, and the average of these measurements taken. The figures obtained were then grouped under the dates of flowering (the flowering and maturation date of each boll being known). The figures for the examination of these are given in the Appendix.

The grouping under date of flowering, and not maturation, is preferable for the purpose desired for the following reasons: (1) The date of flowering is more certain (there is less risk of error) than that of the maturation of the boll. (2) Lint length is governed by conditions during the first half (approximately) of the period of development of the boll, and the actual dates when the length may be affected most are more easily fixed.

For comparison with the Dates of Sowing Series, the Observation Plot Series are charted under their average dates of maturation, the dates for corresponding flowers being given below. These flowering dates are likely to be in close agreement with those for the Dates of Sowing Series, the maturation periods of which were not obtained, and may therefore be applied to the latter also.

Temperatures.

These are advanced in date so that the conditions obtaining during that period of the bolls' development when length is most affected is shown on the date of picking of each sample. Balls* found that the length was developed in the first twenty-one days, the effect being greatest at fifteen to sixteen days old, with an average maturation period of forty-eight days. As the maturation period here is considerably greater, the period in which the length is developing may be expected to be longer. A shift of forty-five days with a maturation period of about sixty-five to sixty-seven days (the actual period of maturation of the bolls which produced the bulk of the

* "Development and Properties of Raw Cotton," W. L. Balls.

[N.B.—The sharp fall in length of the September 7 and second sowings occurring on March 8 may be ascribed to a rather severe Asal attack.]

crop) may be taken to coincide with the important period. The shift would, however, be too great for bolls produced in February and onwards.

A comparison of the lint length and minimum temperatures curves suggests a connection—extra low temperatures tending to produce shorter lint.

Irrigation.

The dates of irrigations are shifted the same period as temperatures, and for the same reason.

They are important for two reasons:

(1) Soil temperatures are lowered by irrigation. With a constant air temperature, a fall of 4° to 5° C. at 12 cms. depth usually occurs within two days of the irrigation; and if this coincides with a considerable fall of air temperatures, a fall of 8° to 9° C. may occur in the same period.

(2) Drought conditions tend to affect lint length. The days immediately preceding an irrigation, particularly with high temperatures, are those on which length is liable to be affected.

Dates when Two-Thirds of the Crop have Matured. (See Fig. 7, "Cumulative Weights of Bolls.")

These dates are taken from the series charted in the above figure. They show the date (to within two to three days) when two-thirds of the total cotton picked up to April 30 had been picked. These figures will not coincide with field figures, as they represent the approximate dates of *maturation*, while ordinary field pickings must always show a lag after these owing to longer intervals between pickings. In addition, picking is not so thorough as on the special observation plants.

Another factor is that the series dealt with are for sowings of the dates given only, there being no resowings. The inclusion of resown cotton, such as occurs under field conditions, will of course produce later pickings.

6. Ginning Outturn. (Note to Fig. 9.)

Measurements were made from cotton from the same series as those employed to obtain the data for Fig. 8 (lint length). The lint-length chart is the same as that in Fig. 8.

The coupling together of the July 22 and August 7-sown cotton may be expected to give a sample of the same average date of sowing as much of the cotton in the Gezira. The August 22 sowing is very near the average sowing date for the Farm, and may be taken as giving an indication of the general characteristics of the Farm cotton as compared with an earlier date of sowing.

Measurements.

Lint Length.—See Note to Fig. 8.

Seed Cotton Weight, Seed Weight, Lint Weight.—One hundred seeds were taken as the standard of comparison.

Three lots of 100 seeds (seed cotton) were picked out at random from the mixed bulk (after cleaning). The seed cotton and seed were weighed together, the seed alone was then weighed after stripping by hand, and the lint determined by difference. The final figures are the means of three determinations in each case. A possibility of error is introduced in regard to the lint weight, but with carefully cleaned cotton this would be very small.

Ginning Outturn.—Ginning Outturn figures were calculated from the above results.

Gezira Figures.—For purposes of comparison, and as some check on the applicability of the results, ginning outturns of Gezira cotton are charted. The figures for Meringan factories, where all the Gezira cotton is ginned, were kindly supplied by the Manager, Sudan Plantations Syndicate, Ltd.

Figures for the average ginning outturns of each factory were available for a series of dates, for each grade. The mean of the figures on each date for all factories was taken, irrespective of grade or amount, and these are charted as representing ginning outturns for the Gezira cotton. The figures for Barakat Tafteesh are also charted as being more comparable to the Farm environment as regards meteorological and cropping conditions.

Gezira and Farm Series: Comparison.—Allowing for variation in the curves produced by the factors of varying amounts of cotton at different periods, and varying proportions of cotton sown at different dates, and by the lag between maturation of the cotton on the plants and its ginning, the Barakat curve on the whole shows a good agreement in shape with the Farm curves.

The main difference lies in the earlier figures, the Farm cotton showing, then, a considerably higher figure. The general agreement of the two series of Farm cottons, however, for this period indicates that these figures are representative samples of the lots examined.

A factor which might produce differences in the direction shown is the loss of weight of the seed due to storing in small lots before examination. From figures kindly supplied by Mr. Craig, Barakat Seed Farm, a loss of weight of bagged seed cotton occurred this season equal to about 1 per cent. or under between weighings at the Seed Farm and at the factory, after storage of about two months. With very small lots this difference is probably accentuated.

At later periods, under drier conditions, this factor is probably of much less importance.

It is understood that the factory figures are taken from sample lots, and are not based on the total figures of cotton ginned.

While there is some doubt, then, as to the values of the earlier figures of the Farm series, the general trend of the latter through the season is confirmed by the Gezira figures. It is a reasonable conclusion, then, that the variance in the characters of the components, which together give the ginning outturn, are of the same general form in both cases.

APPENDIX I.—1926–27.

SINGLE BOLL EXAMINATION (OBSERVATION PLOT 55): LINT LENGTH (see Fig. 8).

Lint length of single-dated bolls, grouped in periods under the dates of flowering: half-millimetre classes.

Series.	1.	2.	3.	4.	5.	6.	7.
Date of flowering	21.10.26 to 27.10.26	1.11.26 to 4.11.26	6.11.26 to 9.11.26	13.11.26 to 18.11.26	20.11.26 to 25.11.26	30.11.26 to 14.12.26	1.3.26 to 28.3.26
Date of maturation	23.12.26 to 28.12.26	4.1.27 to 8.1.27	12.12.26 to 15.1.27	19.12.26 to 24.1.27	26.1.27 to 30.1.27	3.2.27 to 12.2.27	23.4.27 to 18.5.27
Number of bolls	13	40	49	39	26	39	17
Mean (mm.) ..	34·15	33·96	34·12	32·46	31·72	30·02	30·11
Standard deviation	±1·86	±1·65	±1·60	±1·80	±2·50	±2·12	±1·53
Standard error	±0·35	±0·24	±0·23	±0·29	±0·50	±0·55	±0·37

APPENDIX II.—1926–27.

GINNING OUTTURN PERCENTAGES: GEZIRA COTTON (see Fig. 9).

Averages of ginning outturn of Gezira cotton ginned at Meringan factory.

Outturns are obtained from ginned samples, and are not based on figures of all cotton ginned. Outturns for the four factories are averaged with no allowance made for variation in amounts; outturn for different grades included.

	ALL STATIONS (MEAN OF OUTTURN FOR ALL FACTORIES).		BARAKAT.	
Date.	*Rottles of Lint per Kantar Seed Cotton (315 Rottles).*	*Percentage of Lint.*	*Rottles of Lint per Kantar Seed Cotton (315 Rottles).*	*Percentage of Lint.*
22.1.27 ..	—	—	90	28·6
28.1.27 ..	91	28·9	97	30·8
4.2.27 ..	94	29·8	99	31·4
11.2.27 ..	98	31·1	99	31·4
18.2.27 ..	102	32·4	106	33·7
25.2.27 ..	—	—	105	33·3
4.3.27 ..	—	—	106	33·7
11.3.27 ..	104	33·0	107	34·0
18.3.27 ..	105	33·3	108	34·3
26.3.27 ..	105	33·3	108	34·3
31.3.27 ..	106	33·7	105	33·3
24.4.27 ..	103	32·7	103	32·7
22.5.27 ..	102	32·4	100	31·8

APPENDIX III.—Nitrates in Parts per Million: First Foot of Soil.

Plot 38: *Dates of Application of Sulphate of Ammonia.*

Treatment.	*August.*	*September.*	*October.*	*November.*	*December.*
1. Control	9	17	30	48	32
2. 200 rottles sulphate of ammonia applied about August 20 ..	10	31	46	77	55
3. 200 rottles sulphate of ammonia applied about September 4	10	22	34	170	45
4. 200 rottles sulphate of ammonia applied about October 4 ..	8	16	32	83	80
5. 200 rottles sulphate of ammonia applied about November 4	9	15	24	62	37
6. Control	19	12	45	38	20

Means of Plots Manured and Unmanured in Each Month compared (Unmanured=100).

	August.		*September.*		*October.*		*November.*		*December.*	
	Mean.	*Percentage.*	*Mean.*	*Percentage.*	*Mean.*	*Percentage.*	*Mean.*	*Percentage.*	*Mean.*	*Percentage.*
Unmanured	11	100	15	100	33	100	43	100	26	100
No. of plots	5		4		3		2		2	
Manured ..	10	91	16·5	110	37	112	98	228	56	216
No. of plots	1		2		3		4		4	

APPENDIX IV.—SPACING EXPERIMENT PLOT.

Relation of Yields to Proportional Areas Per Plant and Proportions of Number of Plants Per Feddan.

80 cms. between ridges (40 cms. spacing taken as standard=100). Two plants per hole.

Spacing between Holes (Cms.).	*Areas per Plant (Mtrs.²).*	*Proportional Areas per Plant (Approximately).*	*Number of Plants per Feddan (Approximately).*	*Proportional Number of Plants per Feddan (Approximately).*
30	0·120	75	35,100	134
40	0·160	100	26,300	100
50	0·200	125	21,000	80
60	0·240	150	17,500	67
70	0·280	175	15,000	57

CUMULATIVE YIELDS IN ROTTLES PER FEDDAN AND PROPORTIONAL AMOUNTS COMPARED WITH 40 CMS. SPACING.

Picking.	30 *Cms.* = 0·12 *Mtrs.*² *per Plant.*		40 *Cms.* = 0·16 *Mtrs.*² *per Plant.*		50 *Cms.* = 0·20 *Mtrs.*² *per Plant.*		60 *Cms.* = 0·24 *Mtrs.*² *per Plant.*		70 *Cms.* = 0·28 *Mtrs.*² *per Plant.*	
	Yield (Rotls per Fed.).	*Proportion.*	*Yield (Rotls per Fed.).*	*Proportion.*	*Yield Rotls per Fed.).*	*Proportion.*	*Yield (Rotls per Fed.).*	*Proportion.*	*Yield (Rotls per Fed.).*	*Proportion.*
25.12.26 ..	108	142	76	100	50	66	62	82	76	100
6.1.27 ..	386	112	346	100	274	76	274	76	282	82
23.1.27 ..	900	105	862	100	750	87	786	91	740	86
7.2.27 ..	1,148	101	1,138	100	1,104	97	1,090	96	1,046	92
Last picking 9.5.27 ..	1,368	99	1,378	100	1,368	99	1,346	98	1,316	95

SPACING EXPERIMENT IN EGYPT (FROM "ANALYSIS OF AGRICULTURAL YIELD," PART I.).

Spacing Experiment with Egyptian Cotton 1912, carried out by W. L. Balls and F. S. Holton.

Cumulative Yields.—Expressed as number of bolls per square metre.

For the purposes of comparison cumulative totals picked on different dates have been obtained from the tables given for number of bolls per plant per day.

Proportional numbers are given for each total, taking the 0·17 Mtrs.² spacing as standard=100 (approximately the same area as the 40 cms. spacing in the Gezira Research Farm experiment). Two plants per hole.

Picking Date.	1. *Spacing* (0·12 *Mtrs.*² *per Plant*).		2. *Spacing* (0·17 *Mtrs.*² *per Plant*).		3. *Spacing* (0·23 *Mtrs.*² *per Plant*).		4. *Spacing* (0·34 *Mtrs.*² *per Plant*).	
	No. of Bolls.	*Proportion.*	*No. of Bolls.*	*Proportion.*	*No. of Bolls.*	*Proportion.*	*No. of Bolls.*	*Proportion.*
Aug. 13 ..	0·61	149	0·41	100	0·30	73	0·44	107
Aug. 27 ..	3·73	176	2·12	100	1·68	79	2·05	97
Sept. 10 ..	7·64	141	5·41	100	4·45	82	4·40	91
Sept. 24 ..	10·85	123	8·82	100	7·36	83	6·52	74
Oct. 8 ..	12·00	105	11·47	100	9·83	86	8·55	75
Oct. 22 ..	12·93	100	13·00	100	11·52	89	10·22	78
Nov. 5 ..	13·36	98	13·58	100	12·17	90	10·96	81

1926-27.

COTTON.

FLOWER CURVE FREQUENCIES

HEIGHT CURVE - CUMULATIVE.

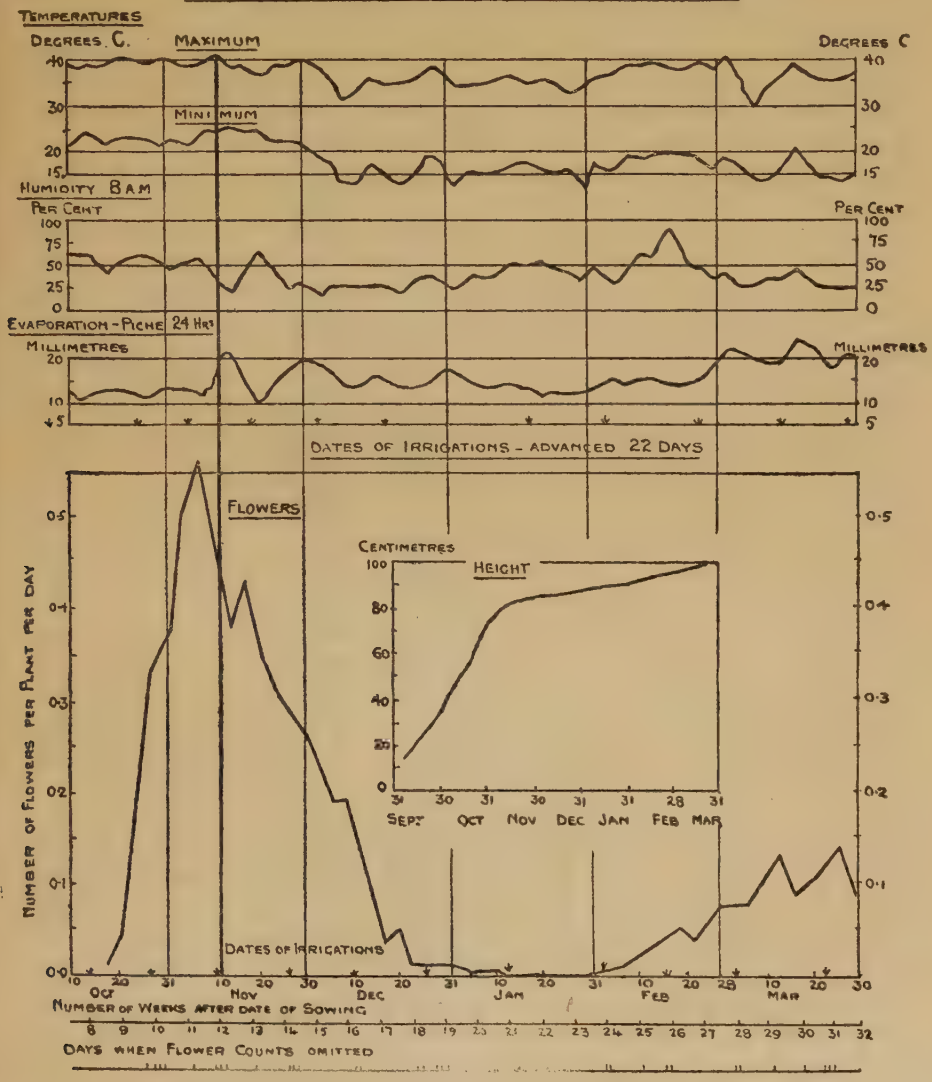
WITH CHARTS SHOWING METEOROLOGICAL CONDITIONS AND IRRIGATIONS, IN RELATION TO FLOWERING

FIG. I.

NUMBER OF PLANTS OBSERVED - 200.

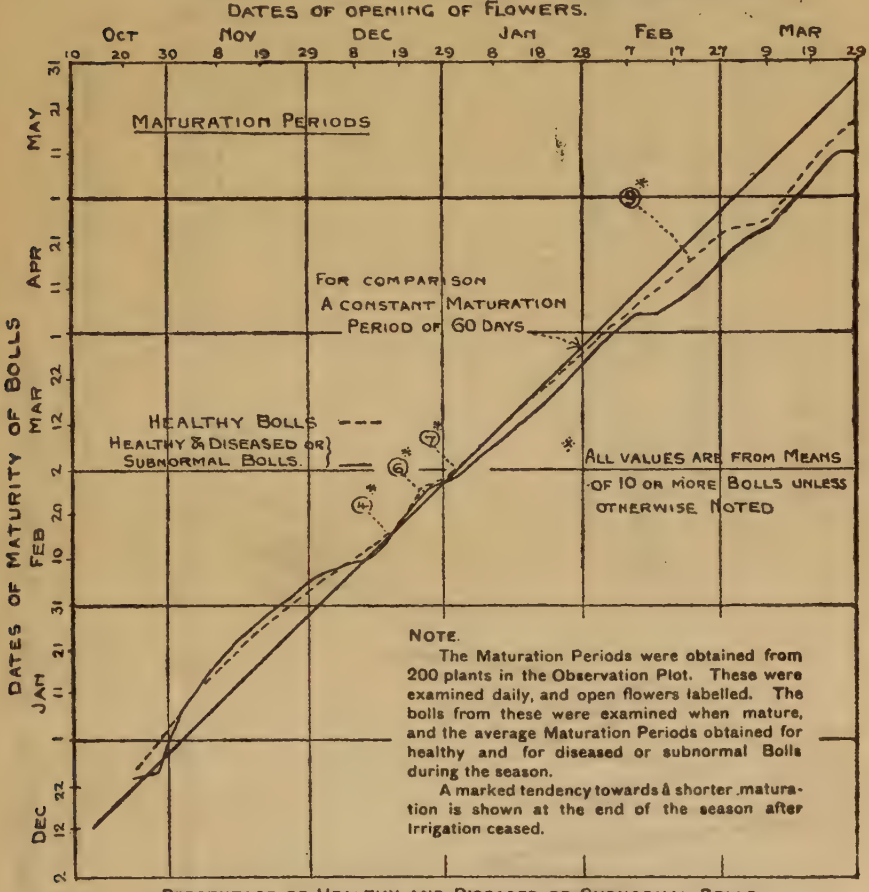
AREA PER PLANT - ·140 METRES^2 3-DAY MEANS.

TEMPERATURE, HUMIDITY, EVAPORATION - ADVANCED 22 DAYS.

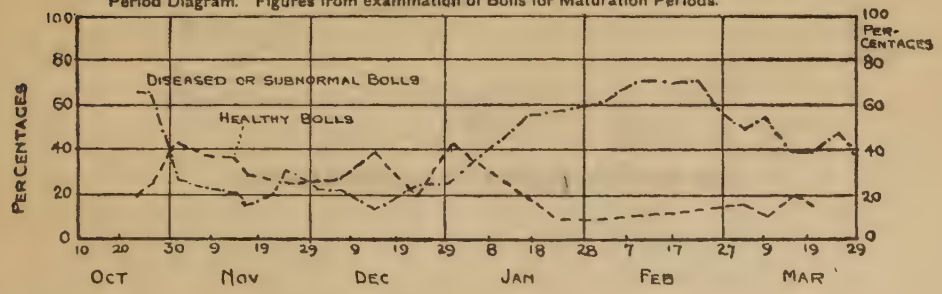


1926-27
COTTON

FIG. 3. MATURATION PERIODS;
AND PROPORTION OF HEALTHY AND DISEASED OR SUBNORMAL BOLLS.
MATURING AT THE DATES CORRESPONDING TO THESE PERIODS


DATES OF OPENING OF FLOWERS.
Oct
Nov
Dec
Jan
Feb
Mar
DATES OF MATURITY OF BOLLS
MAY
APR
MAR
FEB
JAN
DEC
MATURATION PERIODS
FOR COMPARISON
A CONSTANT MATURATION
PERIOD OF 60 DAYS
HEALTHY BOLLS
HEALTHY & DISEASED OR SUBNORMAL BOLLS.
ALL VALUES ARE FROM MEANS OF 10 OR MORE BOLLS UNLESS OTHERWISE NOTED
NOTE.
The Maturation Periods were obtained from 200 plants in the Observation Plot. These were examined daily, and open flowers labelled. The bolls from these were examined when mature, and the average Maturation Periods obtained for healthy and for diseased or subnormal Bolls during the season.
A marked tendency towards a shorter maturation is shown at the end of the season after Irrigation ceased.

PERCENTAGE OF HEALTHY AND DISEASED OR SUBNORMAL BOLLS.
Expressed as percentages of Flowers opened, under dates of opening of Flowers. Dates of maturing of these (Healthy Bolls only) are found by reference to the Maturation Period Diagram. Figures from examination of Bolls for Maturation Periods.



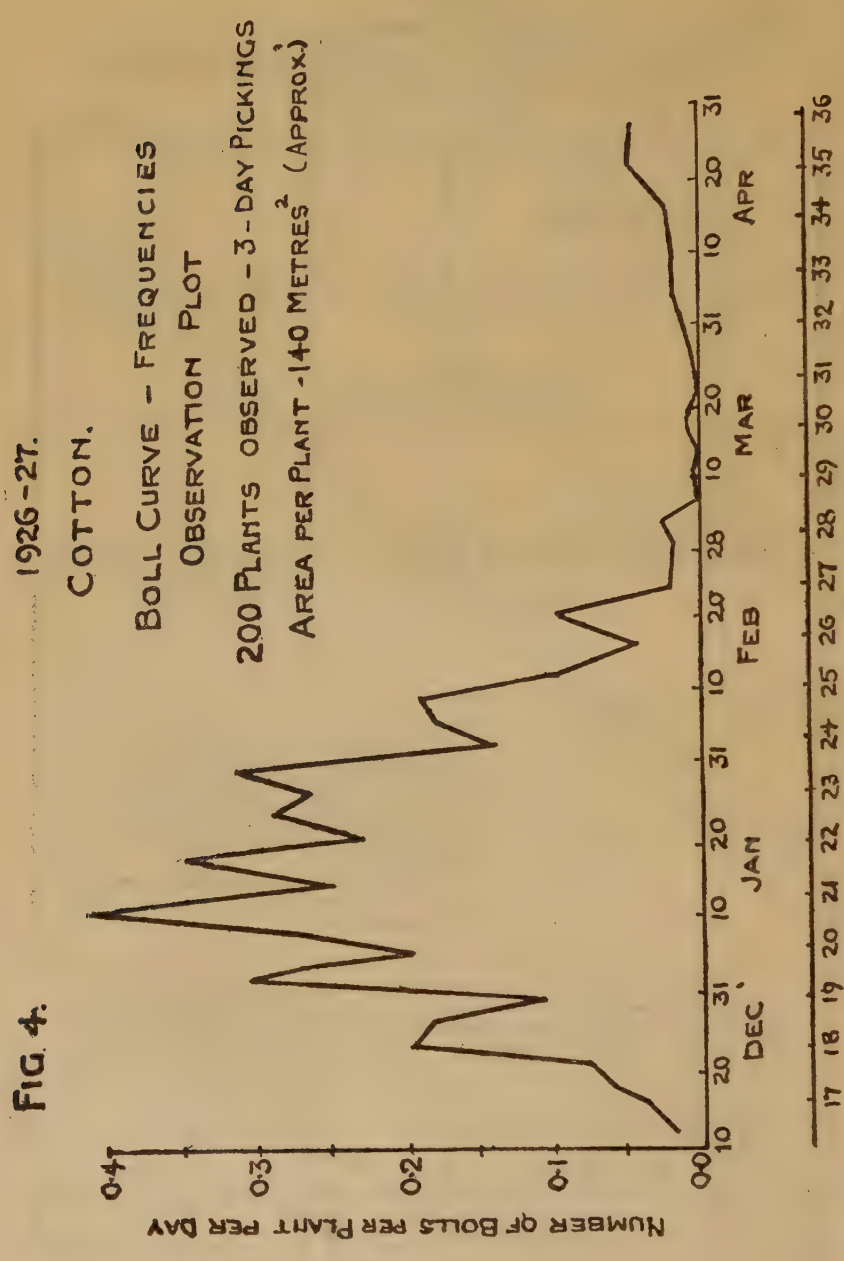


FIG. 4.
1926-27.
COTTON.
BOLL CURVE - FREQUENCIES
OBSERVATION PLOT
200 PLANTS OBSERVED - 3-DAY PICKINGS
AREA PER PLANT - 140 METRES² (APPROX.)
NUMBER OF BOLLS PER PLANT PER DAY
0·4
0·3
0·2
0·1
0·0
10 20 31 10 20 31 10 20 28 10 20 31 10 20 31
DEC. JAN FEB MAR APR
17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
NUMBER OF WEEKS AFTER SOWING.

FIG. 5. 1926-27.

COTTON.

BOLL CURVES – FREQUENCIES

DATES OF SOWING PLOT

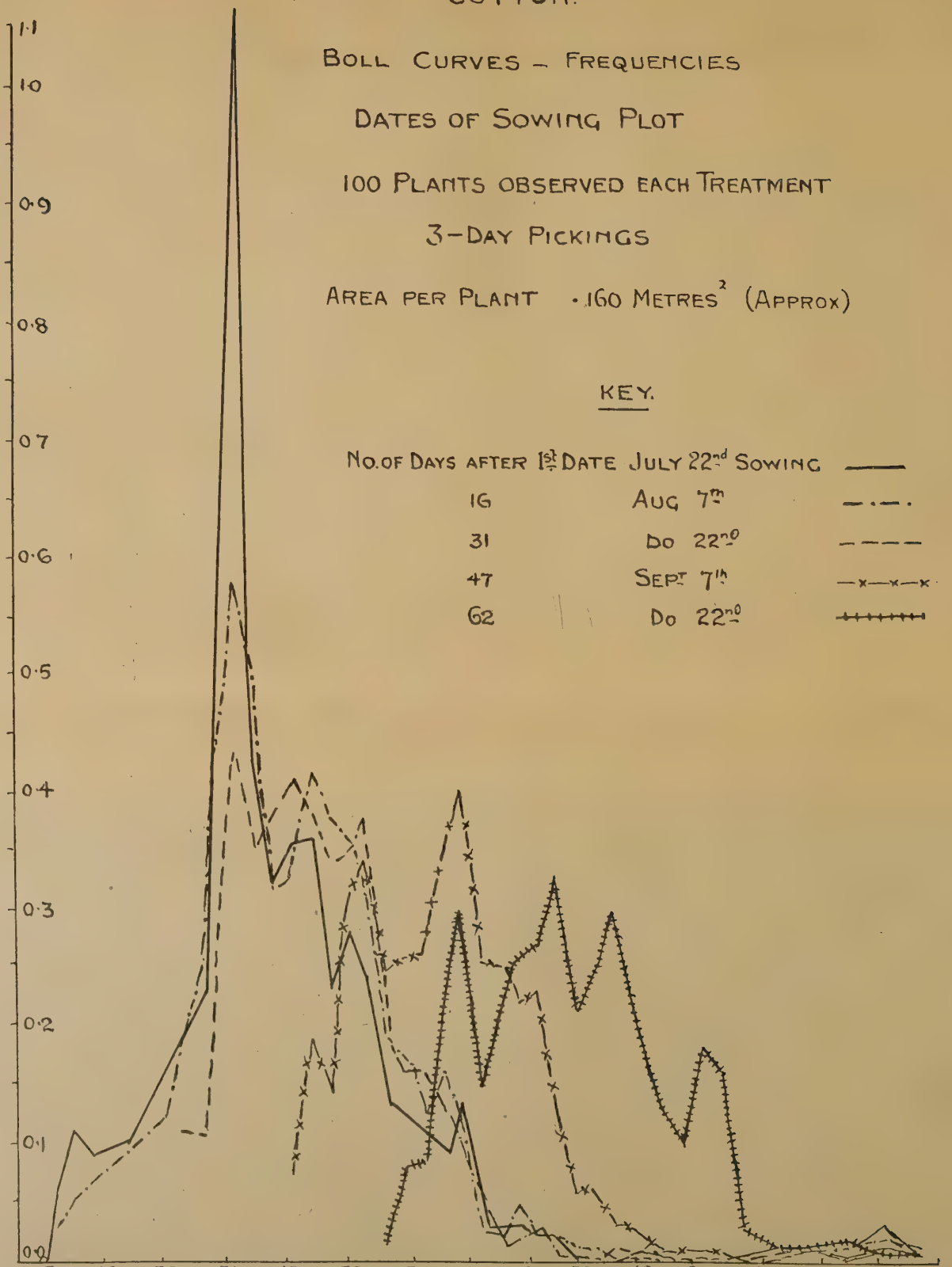
100 PLANTS OBSERVED EACH TREATMENT

3-DAY PICKINGS

AREA PER PLANT .160 METRES^2 (APPROX)

KEY.

NO. OF DAYS AFTER 1st DATE JULY 22nd SOWING		
16	AUG 7th	—.—.
31	DO 22nd	– – – –
47	SEPT 7th	—x—x—x
62	DO 22nd	+++++++

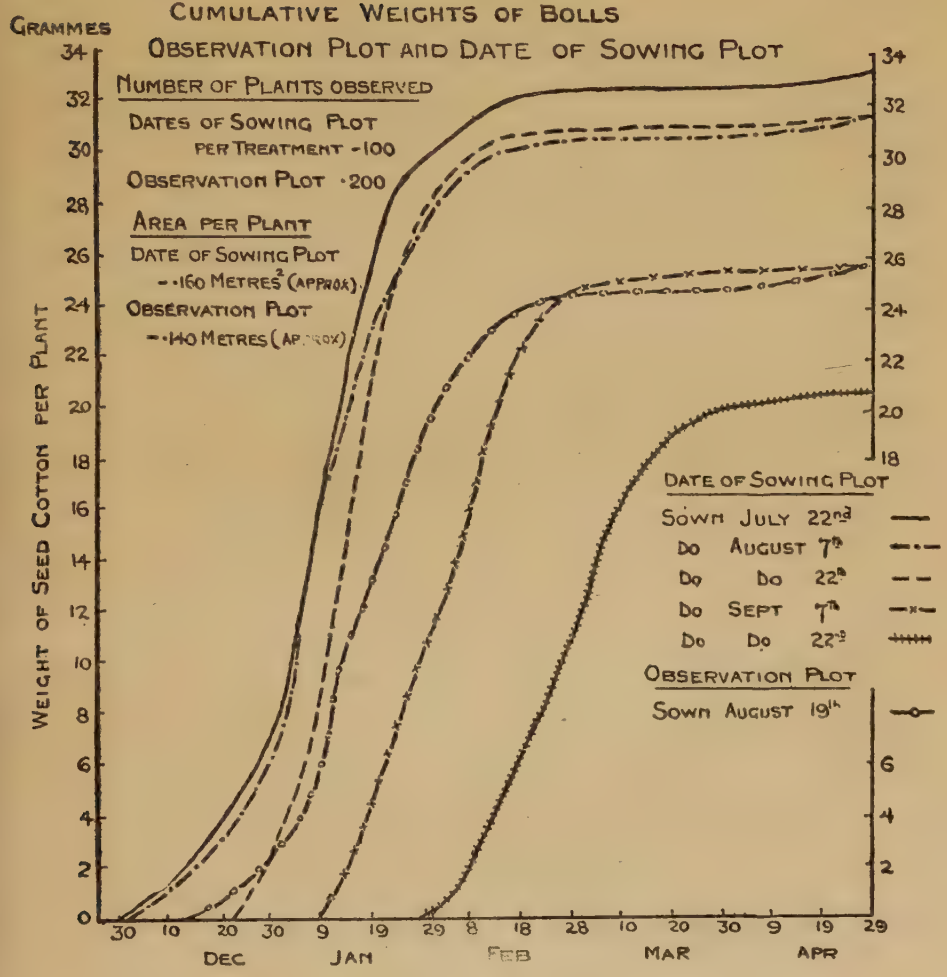


1926 - 27.

FIG 7 COTTON.

CUMULATIVE WEIGHTS OF BOLLS

OBSERVATION PLOT AND DATE OF SOWING PLOT



PROGRAMME OF WORK, 1927-28.

Cotton.

1. *Observation Plot.*

Two hundred plants observed:

(*a*) Flowers—daily.
(*b*) Bolls—daily, or at longer intervals as time allows.
(*c*) Growth—ten-day intervals.
(*d*) Nodal position of oldest leaf—every ten days.
(*e*) Maturation period, flowers to mature bolls—daily.
(*f*) Variation in character of lint and seed through season—*e.g.*, marked bolls obtained under (*e*) to be examined individually (1) for incidence of disease; (2) healthy bolls examined for boll (seed cotton) weight, lint and seed weight, lint length.

2. *Dates of Sowing Plot (Farm Plots).*

Five hundred plants observed:

(*a*) Flowers—three days consecutively, two days not observed. If time allows daily counts made through main period of flower production.
(*b*) Bolls—three to six day intervals.
(*c*) Growth—ten-day intervals.
(*d*) Bolls examined for (1) incidence of disease; (2) healthy bolls grouped for six-day periods and examined for variation in character of cotton through season—*i.e.*, in boll (seed cotton) weight, lint and seed weight, lint length.

3. *Water Interval Experiment.*

Five hundred plants observed:

(*a*) Flowers—daily.
(*b*) Bolls—three to six day intervals.
(*c*) Growth—ten-day intervals.
(*d*) Nodal position of oldest leaf—ten-day intervals.
(*e*) Flowers—as for Dates of Sowing Plot when watering intervals become normal.

4. *Variety Trial Plot: Plant Breeder.*

Strain Trial Plot.—Notes will be made in the course of development in the above plots.

5. *Selections.*

Trial of Blackarm-resistant strains.

Notes and observations will be made on the course of development in the above plots.

Supervision of sowing, watering, and picking will be undertaken by the Botanical Section in the Observation Plot and Selections Plot.

Supervision of sowing and picking will be undertaken in the Water Interval and Variety Plots.

Dura.

6. *Observation Plot.*

Preliminary trial of new types.

7. *Propagation Plot.*

Various selected strains for observation and propagation.

8. *Variety Trial Plot, Non-Irrigated.*
Ditto Irrigated.

Selections will be made from varieties and strains in Propagation and Observation Plots, and from other suitable types grown on the Farm. Observations and notes will be made on the course of development during the season. Supervision of sowing will be undertaken by the Botanical Section of the above plots.

Layout and Treatment.—Given in the Agricultural Experimental Programme.

Explanatory Notes.

Cotton Observation Plot.—The position of this has been altered to the middle of a Continuous Cotton Plot to produce more normal environmental conditions in respect of the shelter effect. The areas and rotation series remain the same.

Water Interval Experiment.—Carried out in co-operation with the Chemical Section.

This is a continuation and modification of experiments made separately last season by the Chemical and Botanical Section. Proper provision will be made for measurement of water, which will be carried out by Dr. Greene, who will also make soil moisture estimations.

The variation in watering intervals will be begun in September, and continued till November, but no definite dates can be laid down, as these depend on the rainfall. For the same reason, the amounts of water to be given cannot be laid down beforehand. As far as conditions allow, the same total amounts of water for the period of the experiment will be given to each variable treatment. At the end of the above period normal watering intervals will be given.

The aim of the experiment is particularly to give information on the relation between the water content of the soil and the development of the cotton plant during the critical period of flower-bud formation and its development to the flowering stage. The method of extra heavy flooding before sowing, which has been shown to increase considerably the water content of the soil at depths below those reached by the usual flooding, will be compared with that of the usual preliminary flooding, and comparison made further between the effects of variation in intervals between irrigations under the latter system.

In connection with this experiment, the Government Botanist will also carry out investigations on the relation between the rate of transpiration of water and temperature in the development of cotton plants.

Dura Observation Plot.

Types under trial will be sown in strips, divided by strips of similar area of a standard variety for purposes of comparison. Special precaution will be taken to eliminate difficulties of comparison due to resowings, on the basis of experience obtained last season. The types under trial include several of those sown last season, with the addition of others.

GEZIRA IRRIGATION SCHEME: SEED FARM REPORT, SEASON 1926-27

BY

J. M. CRAIG,

Inspector of the Sudan Plantations Syndicate in Charge of the Seed Farm.

THE work on the Seed Farm during season 1926–27 is described under the following headings:

A. Propagation of Pedigree Sakel.
B. Propagation of Other Varieties.
C. Main Crop Sakel (Sakel "X").
D. Experiments on the Seed Farm.
E. General.
F. Routine.

A.—PROPAGATION OF PEDIGREE SAKEL.

Section A (300 *Feddans*).—This area was sown with the remainder of the Domains Sakel seed brought from Egypt by Mr. Jefferys in December, 1924. Sowing was from August 15 to 22, but as germination was poor much resow was necessary. All this area except Plot No. 16 (see Experiments, D) was treated with 100 kilos of sulphate of ammonia per feddan. The sulphate was applied just after thinning —*i.e.*, about six to eight weeks after sowing. Each plot was carefully rogued twice in November, by which time the cotton was strong, well branched, and quite free from Blackarm. Picking commenced in January. The yield obtained was 4·85 kantars per feddan, while the range in yield of different hoshas was from 3·68 kantars per feddan to 5·83 kantars per feddan. From this yield 90 ardebs of SAK "W" seed (see under) and 60 ardebs of "X" seed were kept for use on the Seed Farm, while 848 ardebs of "X" seed were obtained for propagation outside of the Seed Farm.

Plot No. 10 was set aside as a nucleus number, and was sown with Domains Sakel which had been hand-picked to get rid of undesirable plants. The seed cotton from this plot was also hand-picked, and the resulting 90 ardebs of seed were marked SAK "W" and kept for propagation on the Seed Farm in season 1927–28.

Yield from Propagation Area:

LINT.

Area.	*Yield.*	*Yield per Feddan.*
300 feddans	1455·16 kantars	4·85

SEED.

90 ardebs	SAK "W"	To seed farm.
60 „	"X"	„ „
848 „	"X"	Propagation outside Seed Farm.

B.—PROPAGATION OF OTHER VARIETIES.

Forty feddans of Nahda (Assili A/22) were sown in Plot No. 3, Section C. This was the only variety other than Sakel grown on the Seed Farm.

The seed used was the remainder of the 20 ardebs of Pedigree Nahda brought from Egypt in December, 1924.

Sowing was from August 15 to 17. Germination was poor and much resow was necessary. The yield was 4·043 kantars per feddan, with a hosha range of 3·11 kantars per feddan to 5·01 kantars per feddan. Only 12 ardebs of seed were kept for further propagation. This seed was marked NHD "W."

The Nahda did not compare favourably with the neighbouring Sakel. Below are given for comparison yields of each hosha in season 1923–24 (when Sakel only was grown) and in 1926–27.

	Yield.		*Yield.*		*Remarks.*
	1923–24.	*Variety.*	1926–27.	*Variety.*	
Hosha 1	32·94	Sakel	50·14	Nahda	
„ 2	20·48	„	44·95	„	
„ 3	16·87	„	35·56	„	
„ 4	11·29	„	31·06	„	
„ 5	19·44	„	53·24	Sakel	
„ 6	18·67	„	48·85	„	
„ 7	16·42	„	50·60	„	Very late cotton and poor stand.
„ 8	21·91	„	40·38	„	
„ 9	21·71	„	36·48	„	

The Nahda never appeared either so healthy or so strong as the Sakel, and it was rather surprising that there was not a greater difference in yield.

C.—Main Crop, Sakel "X."

The remainder of the area was sown with the following strains of Sakel:

1. Sakel R.W.S.
2. SAK "W" 1925–26.
3. Sakel "TX" (old marking).

As these strains were not grown in the Seed Propagation Area, they were known collectively as Sakel "X."

1. Sakel R.W.S. was brought from Egypt in December, 1924, and had been kept at the Seed Farm as a first year reserve. Section B, less Plot No. 2, hoshas 1 to 4, and also Section C, Plot 3, hoshas 5 to 9, were sown with Sakel R.W.S. The germination was extremely bad, and much difficulty was experienced in obtaining a good stand of cotton. After the plant was established, growth was good and branching was fairly good. This crop proved very free from rogue plants, but hardly so good in this respect as the Domains Sakel (SAK "W") of the Propagation Area. No seed was kept from the Sakel R.W.S.

2. SAK "W" (1925–26) was the progeny of the 1925–26 Propagation Area crop, of which 100 ardebs were retained in store as reserve. Section C, Plots 6 and 9, were sown to try out this seed. Sowing was between August 15 to 22, and germination was fair. The plants grew well, but did not appear to branch quite so freely as the Domains Sakel did in the Propagation Area. Very slight Blackarm attack was noticed in two hoshas, but all others appeared quite clean. As was to be expected, a slightly larger percentage of rogues were found here than in the Propagation Area, but the increase was very slight indeed. No seed was kept from this crop.

3. Sakel "TX." The remainder of the area Section C, Nos. 12, 15, and 18, was sown with "X" Egyptian seed, which had been grown once on the Gezira at Tayiba. Sowing was again from August 15 to 22, and the germination was fair. This crop corresponded closely to the SAK "W" (1925–26), although the percentage of rogues in the "TX" was much greater than in the SAK "W."

The yields of the different Sakel "X"s were as under, but, of course, these cannot fairly be compared with one another.

	Yield per Feddan.	*Yield Best Hosha (Kantars per Feddan).*	*Yield Worst Hosha (Kantars per Feddan).*
R.W.S. Sakel	4·18	5·408	2·758
SAK "W" 1925-26 ..	4·62	5·726	3·646
Sakel "TX"	5·24	6·295	3·712

D.—Experiments on the Seed Farm.

1. *Cotton Variety and Strain Test (Checker Board).* (Section C, Plot 18, Hosha 6.)

(*a*) Previous cropping of land.

The only previous crop on this hosha was a cotton crop in season 1923–24, when a yield of 2·684 kantars per feddan was obtained. The average for Barakat Tafteesh that year was 2·99 kantars per feddan.

(*b*) Strains tested were:

1. Egyptian Sakel (Domains Sakel direct from Egypt).
2. Gezira Sakel ("TX" Sakel, grown once at Tayiba).
3. Assili B/22 from Egypt.
4. Nahda (Assili A/22).

(*c*) The layout was as in the table below.

Plan of Cotton Variety Trial (Checker Board Method) (not Drawn to Scale).

From Canal. Abu Ashrin.

Abu Sitta.	Belt Strip.				Abu Sitta.
	5·82* 20 E	5·06 11 A	5·64 10 N	5·48 1 G	
	6·40 19 N	5·82 12 G	5·66 9 E	4·26 2 A	
	5·26 18 G	5·12 13 N	4·60 8 A	4·18 3 E	
	3·70 17 A	4·58 14 E	3·88 7 G	3·14 4 N	
	3·38 16 G	3·18 15 N	2·92 6 A	3·12 5 E	
	Belt Strip.				

Road.

Strains: E=Egyptian Sakel.
G=Gezira Sakel.
A=Assili B/22.
N=Nahda.
Belt Strip=Gezira Sakel (SAK "W").

N

* Yield per plot in kantars per feddan.

Area of each small plot approximate ½ feddan. The usual preparation for cotton was made, and sowing commenced August 17 and finished on August 18. Germination was good and even. Resown on August 27, and watered immediately afterwards.

(*d*) During September the cotton in this hosha did not progress satisfactorily, and much damage was caused by white ant. Blackarm was also active, and mortality among the young plants was heavy. Towards the end of October the appearance of the cotton improved, but the plots to the north of the hosha always remained spindly and stunted. All varieties and strains appeared the same in this respect. Thrips attack was rather heavy in November and December, especially on the north side. Picking commenced on January 21.

YIELD OF PLOTS IN KANTARS PER FEDDAN.

Egyptian Sakel.		*Gezira Sakel.*		*Assili B/22.*		*Nahda.*	
Plot.	*Kantars per Feddan.*	*Plot.*	*Kantars per Feddan.*	*Plot.*	*Kantars per Feddan.*	*Plot.*	*Kantars per Feddan.*
3	4·18	1	5·48	2	4·26	4	3·14
5	3·12	7	3·88	6	2·92	10	5·64
9	5·66	12	5·82	8	4·60	13	5·12
14	4·58	16	3·38	11	5·06	15	3·18
20	5·82	18	5·26	17	3·70	19	6·40
Mean yield of plot ..	4·67	—	4·76	—	4·11	—	4·70
Standard deviation	0·996	—	1·044	—	0·742	—	1·318

Standard error of mean differences between comparable plots based on five plots=0·30.

Variety.	*Mean Yield (Kantars per Feddan).*	*Difference.*	*Difference. Standard Error.*
Gezira Sakel	4·76	—	—
Nahda	4·70	0·06	0·20
Egyptian Sakel	4·67	0·03	0·10
Assili B/22	4·11	0·56	1·88

Gezira Sakel, Nahda, and Egyptian Sakel show practically the same mean yields. The greatest difference is between Gezira and Egyptian Sakel, and is 0·09 of a kantar per feddan. This is only

0·30 of the standard error, so the result cannot be held at all significant.

Assili B/22 shows a mean yield of 4·11 kantars per feddan, or 0·65 kantar per feddan less than Gezira Sakel—*i.e.*, 2·18 times the standard error. This result is probably significant. In last year's Variety Test the difference between these two varieties was 2·91 times the standard error in favour of Gezira Sakel.

2. *Cotton Variety Trial (Strip Method).*

This experiment formed a part of the Government Plant Breeder's variety testing scheme.

1. *Previous Cropping of Plot.*—1923–24, brought into cultivation, Cotton; 1924–27, Rain Dura; 1925–26, Fallow.

2. *Preparation of Land for Cotton.*—Cultivated, October, 1925; ridged, May, 1926; watering before sowing commenced, July 29, 1926; completed, August 6, 1926.

3. *Layout.*—As per Mr. Bailey's Strip Experiment Scheme (see diagram), but with alternate gadwells and tagnets. Seed supplied by the Plant Breeder.

A. Bolland's Sakel No. 8, Plots 4, 11, 14, 24, 31.
B. Massey's Selected Domains Sakel, Plots 6, 13, 15, 23, 28.
C. Main Crop Gezira, Plots 3, 8, 16, 25, 29.
D. Sakel B/24, Plots 7, 12, 17, 20, 27.
E. Massey's Sakel 186, Plots 5, 9, 18, 22, 26.
F. Nahda, Plots 2, 10, 19, 21, 30.
Belt Strip. Gezira Sakel "TX," Plots 1, 32.

4. Sowing commenced August 18, and completed the same day. Unable to carry out double sowing as two of the varieties of seed were not supplied in sufficient quantities.

5. Germination was good in all plots, except 2, 3, and 4. In these three it was only fair, some seed remaining in the solid due to drying out.

6. Completely resown on August 27, followed by a light watering sufficient only to germinate the resow and dried-out seed in the soil.

7. The second watering after sowing was given on September 11. The stand of plant was good, but "Hurug" and/or white ant damage was noticeable at some places, especially in Strip Nos. 9 and 14 slightly damaged, and Strip Nos. 3, 5, 17, and 19 more damaged.

8. *Further Remarks* (*October* 7).—(*a*) The cotton has not come on as one could have wished. It seemed to hang in the spindly stage, and remains pale green in colour.

(*b*) *White Ant.*—Much white ant damage is evident throughout the plot. It is extremely bad in Plots Nos. 2, 3, 4, and 5, and to a lesser extent in Plots Nos. 6 and 7. All plots are attacked to some extent, but one is afraid there will be some blank spaces in the above plots.

(*c*) *Blackarm.*—Examination shows a surprising amount of Blackarm throughout the plot. It is chiefly confined to the stems, and is not common on the leaves. All plots are affected to some extent, but Plots Nos. 13, 17, 20, 22, and 31 are most heavily attacked. Plots Nos. 2, 4, 5, 9, and 10 are perhaps most free from attack.

It is difficult to make out any difference between the varieties, but perhap Sakel B/24 is most affected, while Massey's 186 and Nahda are least.

(*d*) Thrips are present, but the attack is relatively slight.

9. Picking commenced on January 21, and yields per plot were as under:

Bolland's Sakel No. 8.		*Massey's Domains.*		*Main Crop Gezira.*		*Sakel B/24.*		*Massey's Sakel* 186.		*Nahda.*	
Plot.	*Rottles Seed Cotton.*	*Plot.*	*Rottles Seed Cotton.*	*Plot.*	*Rottles Seed Cotton.*	*Plot.*	*Rottles Seed Cotton.*	*Plot.*	*Rottles Seed Cotton.*	*Plot.*	*Rottles Seed Cotton.*
4	222	6	245	3	212	7	225	5	212	2	226
11	292	13	269	8	262	12	245	9	261	10	234
14	242	15	228	16	223	17	195	18	233	19	196
24	195	23	185	25	187	20	235	22	218	21	198
31	138	28	161	29	157	27	166	26	186	30	139
Total..	1,089		1,088		1,041		1,066		1,110		993
Total kantars	3·46		3·45		3·30		3·39		3·52		3·15

Variety.	*Mean per Plot (Rottles of Seed Cotton).*	*Standard Deviation of Plots (Rottles of Seed Cotton).*
Bolland's Sakel No. 8	218	50·98
Massey's Selected Domains ..	218	39·42
Main Crop Gezira	208	35·21
Sakel B/24	213	28·93
Massey's Sakel 186	222	24·72
Nahda	199	33·36

PLAN OF COTTON VARIETY TRIAL (STRIP METHOD).

From canal. Abu Ashrin.

	Belt Strip	1
226	F	2
212	C	3
222	A	4
212	E	5
245	B	6
225	D	7
262	C	8
261	E	9
234	F	10
292	A	11
245	D	12
269	B	13
242	A	14
228	B	15
223	C	16
195	D	17
233	E	18
196	F	19
235	D	20
198	F	21
218	E	22
185	B	23
195	A	24
187	C	25
186	E	26
166	D	27
161	B	28
157	C	29
139	F	30
138	A	31
	Belt Strip	32

Abu Sitta.

Tagnet.

N

Road.

A=Bolland's Sakel No. 8.

B=Massey's Selected Domains Sakel.

C=Main Crop Gezira.

D=Sakel B/24.

E=Massey's Sakel 186.

F=Nahda.

Belt Strip=Gezira Sakel "BX."

Area = 5 feddans—*i.e.*, half hosha.

Figures on left indicate yield in rottles of seed cotton.

Variety.	*Mean Yield (Rottles of Seed Cotton, Kantars).*	*Difference (Rottles of Seed Cotton).*	*Difference : Standard Error.*
Massey's Sakel 186 ..	222	—	—
Bolland's Sakel No. 8 ..	218	4	0·4
Massey's selected Domains..	218	0	0·0
Sakel B/24	213	5	0·5
Main Crop Gezira	208	5	0·5
Nahda	199	9	0·9

Standard error of mean differences between comparable plots based on five plots = 10 (to nearest whole number).

3. *Farmyard Manure Observation Test.*

In accordance with the Managing Director's wishes, the effect of farmyard manure was tried on an area of the Seed Farm. Unfortunately, owing to the difficulty of obtaining F.Y.M. in sufficient quantities, only 20 feddans were treated instead of the desired 60.

Section A, No. 16, was chosen, as this number shows up relatively uniform in the yield records, and the tenants were uniformly good.

Farmyard manure was obtained from a cattle compound and appeared good but rather old. The manure was applied to the third and fifth hoshas in early July at the rate of approximately 4 tons per feddan; the cost of collecting, breaking up, and applying was roughly 50 p. a feddan. The fourth hosha acted as a control, while the second and sixth hoshas were treated with 100 kilos of sulphate of ammonia per feddan six weeks after sowing.

All hoshas were otherwise treated exactly the same. Unfortunately white ant proved very destructive, especially in the F.Y.M.-treated hoshas. This resulted in a noticeably poorer stand of plant in these two hoshas than in the control. The sixth hosha is lower in level than the others, and the cotton there was much later and slower in coming away, so the result from it cannot be fairly compared to that from the other hoshas of the number.

All hoshas did well, but no difference in strength of growth between the control and treated hoshas was observed:

Hoshas yielded as under:

Second Hosha,	52·03	kantars	.. ..	Sulphate of ammonia treated.
Third „	46·98	„	.. ..	Control, no treatment.
Fifth „	52·13	„	.. ..	F.Y.M. treated.
Sixth „	46·87	„	.. ..	Sulphate of ammonia treated.

Hoshas' record:

	1914–15.	1916–17.	1919–20.	1923–24.	1926–27.
Second Hosha ..	62·60	32·90	43·70	33·98	52·03†
Third „ ..	60·50	35·08	46·00	34·82	46·98*
Fourth „ ..	58·90	28·81	43·26	38·79	54·77†
Fifth „ ..	58·80	25·10	37·73	32·81	52·13*
Sixth „ ..	64·60	22·02	38·32	36·65	46·87†

4. *Flooded Number.*

No 9 of Section C was flooded from July 2 to August 4. The number was sown on August 16 to 18. Yields of this and neighbouring numbers are given below:

	Yields, 1923–24 (*Kantars per Feddan*).	*Yields*, 1926–27 (*Kantars per Feddan*).	*Percentage Increase* 1926–27 *over* 1923–24.
Section C No. 6 ..	2·40	4·73	97
„ C No. 9 ..	2·42	4·50‡	87‡
„ C No. 12 ..	3·57	5·64	58

While no effect by flooding can be detected on the final yield, the flooding had the effect of greatly reducing the germination of annual weeds, and thus saved much labour at sowing time.

5. The Propagation Area was treated with sulphate of ammonia at the rate of 100 kilos per feddan. This was not a yield experiment, and was not set out as such, but was carried out as it was thought possible that it would have a beneficial effect in producing a Blackarm-free plant.

Below is given an analysis of the yields obtained. Only one hosha in the 300 feddans was not treated, and it yielded 5·48 kantars per feddan.

	Yield per Feddan.
300 feddans treated with sulphate of ammonia	4·83
925 feddans (remainder of Seed Farm growing Sakel), not treated	4·55

These areas are made up of old Barakat numbers (north of disused Barakat Main Canal) and new numbers. For a purpose of comparison the old and new are analyzed separately. The average Gezira yield for each year is given, but this figure cannot fairly be used for comparison with the yields of treated Barakat Plots; it merely serves to indicate whether the year was a good or bad cotton year.

* Farmyard manure treated. † Sulphate of ammonia treated.
‡ Flooded number.

OLD BARAKAT AREA: COMPARISON OF YIELDS (AVERAGE KANTARS PER FEDDAN).

	Plot.	*Area.*	1914–15.	1916–17.	1919–20.	1923–24.	1926–27.
Average yield for Gezira ..	—	—	5·39	3·20	4·98	2·98	4·74
Barakat No. 1 Canal ..	A/10/1–6	60	5·11	2·89	5·75	3·83	5·24*
	A/13/1–6	60	6·07	3·19	5·18	3·70	5·08*
	A/16/2–6	50	6·11	2·97	4·18	2·95	5·06*
Barakat No. 2 Canal ..	B/8/2–10	90	2·26	—	5·22	3·03	3·83
	B/11/1–10	100	2·62	—	4·10	2·58	3·97
	B/14/1–10	100	—	—	—	4·06	4·01

	1914–15.	1916–17.	1919–20.	1923–24.	1926–27.
Average yield for Gezira ..	5·39	3·20	4·98	2·98	4·74
"W" area old numbers (as above) of Barakat I. Canal	Other varieties than Sakel		5·09	3·53	5·13†
"Z" area old numbers (as above) of Barakat II. Canal	Other varieties than Sakel		4·63	3·23	3·94
"W" compared to "Z"	Not comparable		+0·46	+0·30	+1·19

NEW AREA: COMPARISON OF YIELDS (AVERAGE KANTARS PER FEDDAN).

	Plot.	*Area.*	1923–24.	1926–27.
Average yield for Gezira	—	—	2·98	4·74
Barakat No. 1 Canal and Wad Medani Tail Canal	A/1/1–6	30	2·27	4·56†
	A/4/1–6	60	2·69	3·96†
	B/2/1–4	40	2·86	5·20†
Remainder of Wad Medani Tail Canal	B/2/5–9	57	2·80	3·71
	B/5/1–7	69	2·81	4·41

Summary of above:

	1923–24.	1926–27.
Average yield for Gezira	2·98	4·74
"W" area new numbers of Barakat No. 1 Canal and Wad Medani Tail Canal	2·65	4·48‡
"Z" area new numbers of Wad Medani Tail Canal ..	2·80	4·09
"W" compared to "Z"	−0·15	+0·39

Area on which sulphate of ammonia was applied difference 0·54 kantars per feddan.

6. Seed supplied by the Managing Director of twelve varieties of leguminous plants was tried out. None of the varieties proved to be at all suitable to the Gezira.

* Sulphate of ammonia-treated area.

† Area on which sulphate of ammonia was applied.

‡ Area on which sulphate of ammonia was applied. Difference 0·54 kantars per feddan.

E.—General.

In accordance with the programme for the Seed Farm 1926–27 crop, the cotton area was well watered and sowing only commenced on August 15; 52 mm. of rain fell on August 5 and 38·5 mm. again on August 13, so it was fortunately possible to sow the entire crop between August 15 and 22. After sowing the only rain to fall was:

	4 mm. on August 26.
	2 mm. on September 12.
	4·5 mm. on October 28.
	2 mm. on October 30.
Total	12·5 mm.

Unfortunately germination was poor and much resowing was necessary. The bad germination was probably due to the very dry conditions after sowing and in many cases to bad sowing. Heavy resowings were necessary all September, when much damage was caused by white ant. During October the young plant began to pick up, and towards the end of that month made rapid headway. By November the crop looked well, was dark green, strong, and branching well. No angular leaf-spot or Blackarm lesions were observed in any strain except the SAK "W" 1925-26 and Sakel "TX," and in these crops the attack had been very slight and was, apparently, no longer active.

Very little square and boll shedding was observed, although a certain amount due to caterpillar damage was noted. Towards the end of November yellowing of plants began to be noticed, and by the middle of December this yellowing had increased, but was confined chiefly to Section B, No. 8, and Section C, No. 9, and to a lesser degree to the Nahda. The yellowing was accompanied by leaf fall which increased as the season progressed. Thrips attack became general in December, and by the end of that month had done much damage, especially to the north and east sides of numbers. Picking commenced about the beginning of January and continued until the crop was cut out at the end of May—February and March being the rush period.

The yields were as follows:

	Kantars per Feddan.
1. Section A (Seed Farm Propagation area, SAK "W") ..	4·83
2. Sections B and C (Main Crop, Sakel "Z")	4·55
3. Nahda (Assili A/22)	4·04
Average yield whole area	4·61

The hosha range in each case was as follows:

	Worst Hosha (Kantars per Feddan).	*Best Hosha (Kantars per Feddan).*
SAK "W"	3·68	5·83
Sakel "Z"	2·758	6·295
Nahda	3·106	5·014

The Propagation Area (300 feddans) was treated with 100 kilos of sulphate of ammonia per feddan. This was not an experiment, but, together with late sowing, was an attempt, as far as possible, to have a Blackarm-free Propagation Area.

The sulphate of ammonia was applied about six to eight weeks after sowing, and as far as possible fairly closely before watering. The effect of the manure was soon apparent, and, in fact, all through the season the treated area was conspicuous. The plants were strong and healthy, branched well, and apparently well covered with bolls. The appearance of the growing crop led one to believe that the difference in yield between treated and untreated would be considerably greater than it ultimately was. No Blackarm was noticed on the treated cotton, but in this respect it differed hardly at all from the untreated. Comparative yields of the treated and untreated cotton have been given above (Experiments on Seed Farm, 6).

The most noticeable difference between the 1925–26 crop and that of 1926–27 was the freedom from Blackarm in the latter season. Possibly to this alone can be credited the increase in yield from 3·5 kantars per feddan to 4·6 kantars per feddan. Whether this freedom from Blackarm in 1926–27 was altogether or in part due to the precautions taken (*i.e.*, late sowing and a stimulation with artificial manure), or whether it was due to the different climatic conditions, it is impossible to say. It is, perhaps, significant that the growing 1926–27 crop was subject to practically no rain, and the little there was, was very light.

The hosha range in the two seasons differs widely:

	Best Hosha.	*Worst Hosha.*
1925–26	6·875	0·953
1926–27	6·295	2·758

Really, in 1926–27, the best hoshas were not quite so good as in the previous seasons, but there were no very bad hoshas at all (hoshas that gave practically no yield due to heavy Blackarm attack). It should not be lost sight of, however, that all best hoshas of 1926–27 were also late sown.

Comparison of the yields of the Seed Farm with those of Barakat Tafteesh, of which the Seed Farm used to form part, is interesting:

	1924–25.	1925–26.	1926–27.
Barakat Tafteesh ..	2·29	3·80	3·58
Seed Farm	2·09	3·50	4·61*

Of course, these figures are not fairly comparable, but the indication is certainly in favour of late sowing in a season like the past one.

F.—Routine.

Mr. Wimshurst left the Seed Farm in December, 1926, on being posted to Galil Tafteesh.

Mr. Guest joined the Seed Farm as Assistant Inspector on December 20, 1926.

A general scheme for seed supply to the Gezira and a scheme of seed marking was submitted for approval in December, 1926.

* Sown after August 15 only; remainder normal sowing, early—late.

SEED FARM PROGRAMME, SEASON 1927-28

A.—Propagation Area.

1. The Seed Farm Propagation Area (Section A and Section B, Plots 1 and 4, giving in all 441 feddans) will be sown with Sakel "W" 1926–27—*i.e.*, with the pedigree seed from the previous season's nucleus number.

Twelve ardebs of this seed to be hand-picked and marked V. This V seed will form the nucleus seed, and will sow Section A, No. 9 (60 feddans).

It is further suggested that a hosha of 10 feddans within this nucleus number should be set aside for detailed personal rogueing. This hosha would act as a nucleus within the nucleus, and seed from it would sow the whole nucleus area in the following season.

The ordinary routine for rogueing, etc., would be carried out in the nucleus area, but the very much greater supervision possible on the 10 feddans area should materially help to keep up the purity, as all seed from the Seed Farm would be ultimately the progeny of this small area. The disadvantage of a year longer on the Seed Farm, of course, does not come into play, as no outside source of seed for the Propagation Area is so far possible.

2. The estimated yield from Section A this season is 800 ardebs of Pedigree Sakel Seed.

Of this amount:

(*a*) 90 ardebs will be necessary to sow the Propagation Area.
(*b*) 60 ardebs will be necessary as a store reserve.
(*c*) This leaves 650 ardebs available for propagation outside of the Seed Farm. This seed will be marked "X."

B.—Other Variety Area.

1. *Section C, No.* 13.—It is suggested that the variety Nahda (Assili A/22) be discarded. This variety has been tried out during the last two seasons, and has both years been inferior to Sakel. A reserve of 8 ardebs of seed could be retained in the store for one season.

2. It is recommended that 40 feddans of "Marad" be sown in order to try this variety under Gezira conditions, and to form a nucleus stock if this is found desirable.

C.—Checker Board Experiments.

Two hoshas (Section C, No. 16, hoshas 6–7) are set apart for these experiments.

One of the hoshas is reserved for a variety experiment to be set out by the Government Plant Breeder. This plot forms one of a set of three exactly similar experiments—the others being at the Gezira Research Farm and Shambat.

Sakel Strains and Marad Strip Test.

Strain A	.. ..	Marad seed from Egypt.	
„ B	.. ..	Kassala Sakel seed from	Kassala.
„ C	.. ..	Tokar „ „	Tokar.
„ D	.. ..	Egyptian „ „	Egypt.
„ E	.. ..	Gezira „ „	Gezira (SAK " W " 1926-27).

This test will compare the relative yielding capacity of Sakel seed from the different sources, Kassala, Tokar, Egypt, and the Gezira, and will also try out the variety Marad.

Each strain will be sown in six separate plots, and the distribution will be as in the diagram on p. 81.

The strip arrangement of plots has been suggested instead of the regular chessboard layout, as during the past season the former was found to be more easy to supervise and to inspect without loss of accuracy.

Area of experiment	5 feddans.
„ each strip	750 square metres.
„ „ variety	$1\frac{1}{14}$ feddans.

D.—Remainder of Area: 840 Feddans.

It is suggested that this should be sown with the different imported seed—*i.e.*, seed from Kassala, Tokar, and Egypt.

This would greatly facilitate the determination of the purity of these strains, and in the case of the Kassala and Tokar seed may lead to the detection of a source of impurity.

As Section B, Plot 7, hoshas 9–10 (30 feddans) is in close proximity to the Propagation Area, it is proposed that Sakel " W " 1925–26 should be sown in this plot; Section B, Plot 17, hoshas 8–10 could also be sown with this seed.

This leaves 780 feddans to be sown with Kassala, Tokar, and Egyptian seed. If these different strains are sown in alternate hoshas, useful data will probably be gathered as to their relative yielding capacity, resistance to diseases, etc.

If Egyptian seed is not available, seed from this season's Wad Naaman crop (" WX ") will be substituted.

E.—General.

The result aimed at by the general recommendations last year—namely, a Blackarm-free plant—has been attained in the present season. How much, if at all, this was due to these recommendations and how much to the season it is impossible to say, but, on the other hand, nothing has occurred to suggest that these recommendations are unsound; therefore it is suggested:

1. All areas of the Seed Farm growing seed for propagation should be particularly well flooded, and the date of sowing delayed so that it only commences about August 15.

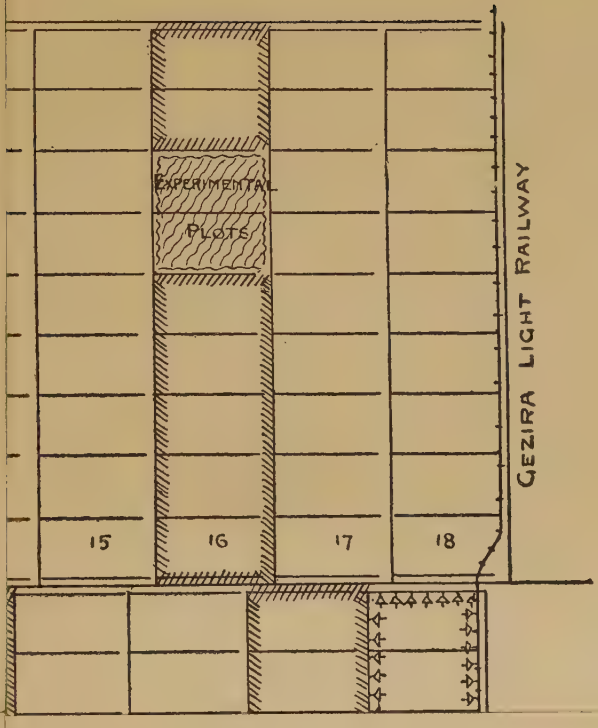
2. That the Propagation Area be treated with 100 kilos of sulphate of ammonia per feddan.

This was carried out in the past season with what appears to be great success.

F.—Seed, etc., Required.

1. Pedigree Sakel	..	150 ardebs (SAK " W " 1926-27).
2. Kassala „	..	60 „
3. Tokar „	..	60 „
4. Egyptian „	..	60 „
5. Sulphate of ammonia	..	45 tons.

March 18, 1927


EXPERIMENTAL
PLOTS
15
16
17
18
GEZIRA LIGHT RAILWAY

PLAN OF STRAIN TEST LAYOUT.

Abu/20.

Abu Sitta.

Belt Strip	1
A	2
B	3
C	4
D	5
E	6
B	7
A	8
D	9
E	10
C	11
E	12
D	13
B	14
C	15
A	16
D	17
C	18
E	19
A	20
B	21
C	22
E	23
A	24
B	25
D	26
Belt Strip	27

Area=5 feddans (280 by 75 square metres).

Number of strips=25 + 2 belt strips=27.

Length of each strip = 75 metres.

Width of each strip = 10 metres.

Width of Belt Strips = 15 metres.

Area of each strip=750 square metres.

Number of varieties=5.

REPORT ON CHEMICAL AND ENTOMOLOGICAL RESEARCH WORK IN CONNECTION WITH THE GEZIRA, 1926-27

BY

MAJOR R. G. ARCHIBALD, C.M.G.,
Director of the Wellcome Tropical Research Laboratories.

STAFF.

AN additional assistant chemist, Mr. R. H. Peto, was appointed for duty at the Gezira Research Farm.

MEETING OF RESEARCH WORKERS.

The meeting held at the Research Farm in the previous season afforded opportunities for discussions on various aspects connected with cotton research. In January of this year another meeting, which was well attended by the Research Staff and Inspectors of Agriculture, took place in the Gordon College, with Mr. Hewison, Director of Agriculture and Forests, in the chair. Papers were read and discussed, and field and laboratory demonstrations followed at Shambat Research Farm. It is hoped to hold these meetings annually.

The following papers were read, and are being embodied in a separate publication:

1. "Cotton-Growing at the Gezira Research Farm, with a Brief Account of Some of the Experimental Plots." By V. P. Walley, Chief Inspector, Gezira Research Farm.
2. "Recent Studies in Plant Physiology and Pathology." By R. E. Massey, Botanist, Sudan Government.
3. "The Study of Parasitic Insects and their Economic Importance in the Sudan." By H. Bennet Johnston, M.A., Assistant Entomologist, Sudan Government.
4. "An Account of Some Moisture Investigations carried out at the Gezira Research Farm." By Dr. H. Greene, M.C., Ph.D., B.Sc., Assistant Chemist, Sudan Government.

WORK OF THE SEASON 1926–27.

The extra accommodation and equipment at the Research Farm and an additional chemist afforded facilities for attempting a larger research programme; the co-operation of the Director and Staff of

the Agricultural Department and the Staff of the Plantations Syndicate rendered this possible.

Special thanks are due to Mr. V. P. Walley, Chief Inspector, Gezira Research Farm, for his unfailing and sympathetic assistance to the research staff of the laboratories. His advice and help in all matters connected with the Farm have been invaluable.

Extension of the Canalized Area.—The proposed extension of the canalized area necessitated a further soil survey being carried out which increased considerably the work of the Government Chemist, Dr. Joseph, and the members of the chemical staff, notably Dr. Greene, whose investigations have added considerably to our knowledge of the physics and chemistry of the Gezira soil.

Chemical Research.—Investigations have been carried out on the following: (1) Vertical movement of the salts under irrigation. (2) Relation between salt content and yield. (3) Soil moisture. (4) Penetration of irrigation water, vertical and lateral. (5) Penetration of water following various cultural treatments. (6) Flooding experiments. (7) Permeability of Gezira soil to water. (8) Nitrate content of Gezira soil. (9) Influence of moisture content on nitrification. (10) Seasonal variation of nitrate content. (11) Various experiments with gypsum.

The Value of Gypsum.—The value of gypsum as a soil corrective in the Gezira was noted in the year 1911 by the late Dr. Beam. This has been confirmed by subsequent experiments, which have also established the value of this salt in improving the permeability of soil to water.

Application of Gypsum in Areas with Low Yields.—Although further information is required as to the best method of applying gypsum, trials in the meantime might be commenced with advantage in certain parts of the canalized area, which have given low yields, and where the soil conditions approximate to those examined at Ganib (*vide* p. 105).

Entomological Research.—Mr. H. B. Johnston, who returned from a period of study leave at various research stations in America, now supervises the entomological work in the Gezira. Steady progress has been made in the study of the various pests and their control, and it is probable that additional staff will be required for this section. Special work is being carried out in connection with the Pink Bollworm, a pest which has become established in the Gezira. Mr. Johnston's initial researches on the parasitization of the Cotton Stem-borer and other pests are important, and may have far-reaching results in controlling certain cotton pests in the Gezira.

Medical Research in the Gezira.

Matters affecting the health of the Gezira population are frequently referred to me by the Director of Medical Services, and during my visits to the Gezira opportunities have been taken of studying some of the existing medical problems.

The existence of the Bilharzial-carrying mollusc or snail in the irrigation canals raised the question of the spread of Bilharzia among the Gezira population. A Committee, including the Director of Medical Services and myself, was formed to consider the best means of dealing with the question. Researches on the life-history of the mollusc were carried out in the laboratories and methods devised for collecting and destroying the molluscs in the irrigation canals. It is satisfactory to note that these methods have been applied on a large scale and have proved a success; inspection and treatment centres of infected natives have also been established. The danger of the spread of Bilharzia, if not entirely averted, is now well under control.

Recommendations.

(1) *Plant Physiologist.*—During the past few years the environment of the cotton plant has been extensively studied. Little or nothing, however, is known of its physiology. If the various factors influencing growth and yield in the Gezira are to be correlated correctly, a knowledge of the plant's physiology from seedling to maturity is a *sine qua non.*

In my opinion, a plant physiologist is required; valuable data could be obtained after two years' work based on carefully planned experiments.

(2) *Co-operation with Research Institutions in England.*—Two months' work at Rothamsted this year has enabled me to view the possibilities of co-operation on the part of this research institution in some of our problems.

Glasshouses have now been erected there for the growing of cotton plants under the supervision of Mr. Stoughton, who has already commenced investigations on cotton diseases.

Certain diseases dependent on soil temperature could well be studied there provided Wisconsin tanks were erected.

It is hoped in the coming season to take up the study of the bacteriology and protozoa of the soil in the Gezira; every assistance has been assured me by the staff of Rothamsted.

Publications in Connection with Research Work in the Gezira, Season 1926–27.

1. "The Sulphuric Acid Treatment of Cotton Seed." By R. G. Archibald. *Soil Science*, vol. xxiii., no. 1, January, 1927.
2. "Blackarm Disease of Cotton, with Special Reference to the Existence of the Causal Organism *B. malvacearum* within the Seed." By R. G. Archibald. *Soil Science*, vol. xxiii., no. 1, January, 1927.
3. "The Organic Matter in Heavy Alkaline Soils." By A. F. Joseph and B. W. Whitfield. *Journal of Agricultural Science*, vol. xvii., part i., January, 1927.
4. "The Moisture Equivalent of Heavy Soils." By A. F. Joseph. *Journal of Agricultural Science*, vol. xvii., part i., January, 1927.
5. "A Note on Locusts." By H. B. Johnston.
6. "A Simple Form of Distributor for Insecticide Dusts." By H. H. King and H. B. Johnston.
7. "Black Rot of the Castor Oil Plant in the Gezira." By R. G. Archibald. *Trinidad Journal of Agriculture.*
8. "Cotton-Growing at the Gezira Research Farm, with a Brief Account of Some of the Experimental Plots." By V. P. Walley.
9. "Recent Studies in Plant Physiology and Pathology." By R. E. Massey.
10. "The Study of Parasitic Insects and their Economic Importance in the Sudan." By H. B. Johnston.
11. "An Account of Some Moisture Investigations carried out at the Gezira Research Farm." By H. Greene.

Nos. 8, 9, 10, 11 are included in a special publication now in the press.

WORK OF THE CHEMICAL SECTION

BY

DR. A. F. JOSEPH,

Government Chemist.

EXTENSION OF THE SOIL SURVEY OF THE GEZIRA.

The projected further development of irrigation in the Gezira necessitated an extension of the soil survey of the western part of the area.

About 120 4-foot holes have been sampled, the area covered being roughly a quadrilateral, whose corners are Lat. 14° 12′ N., Long. 32° 26′ E.; 14° 42′ N., 32° 26′ E.; 14° 52′ N., 33° 0′ E.; and 14° 26′ N., 33° 0′ E. The results show that the western position is lighter in texture than the eastern. Thus along parallel 14° 27′ A., the average clay content for the first foot of eight holes was 42 per cent., while the average clay content at about the same latitude in the canalized area (forty miles further east) was 58 per cent. For the same holes the average soluble salt content (to 4 feet) was 0·373 per cent. for the western part, and 0·233 per cent. for the eastern.

Similar differences have been observed along one or two other lines, but further sampling is required before any generalization can be made with certainty.

It will also be necessary to determine whether the nature of the salts (alkalinity and ratio of calcium to sodium) is the same in different parts of the Gezira.

Some of the soils near the west bank of the Nile show a very high clay content ; in one hole the average for the 4 feet was 82·5 per cent., and in another 71·4 per cent. of clay. Some of the samples showed correspondingly high moisture equivalents (61·5 and 58·3) without waterlogging.

MECHANICAL ANALYSIS OF SOILS.

During the year the laboratory took part in the co-operative testing of methods for mechanical analysis of soils organized by the first Commission of the International Society for Soil Science, three soils being tested by four methods, to which the Sudan method (sodium carbonate) was added for comparison. The results for the percentage of clay show that the Sudan method with its advantage of great simplicity was satisfactory.

The Composition of Soils and Clays.

The chemical composition of the Gezira soil has been previously recorded. Analyses of the salt and clay fractions have been carried out for other soils—viz., Tokar alluvium from the Gash, Blue Nile alluvium near Khartoum, White Nile alluvium near Khartoum, and an outsoil from Mongalla. A subsoil sample taken at the 10th foot at Tayiba gave the following:

Sand and Gravel.	*Coarse Sand.*	*Fine Sand.*	*Silt.*	*Clay.*
1·0	7·4	38·5	20·9	32·0

Figures for the analyses of the other above-mentioned soils are given in the Appendix of the Report of the Government Chemist, 1926, pp. 30-31.

Investigations on the Moisture Equivalent of Soils.

The work carried out in previous years has been embodied in a paper, of which the following is a summary:

1. The moisture equivalent of pure clay preparations varies with (*a*) the chemical composition; (*b*) method of separation if centrifuged; (*c*) the replaceable bases.

2. The imbibitional water content also shows a close connection with the above variables.

3. Good additive relationships can only be obtained from series of soils of the same nature, and in some cases if taken at the same depth. This is at any rate in part due to differences existing in composition and properties between clay separated from soils and subsoils.

4. Pure silt fractions from different soils show marked differences in the chemical composition and moisture equivalent.

Effect of Storage on Soils.

Of the soil reported impermeable in 1924 the stock of three has been exhausted, one remains still impermeable, and the other two are obviously becoming more permeable. At the end of 1926 only two were left, and these are becoming permeable. The four soils which appeared to be increasing their moisture equivalent have now become practically stationary. In order to continue further observations on the effect of storage on soils, larger samples of two soils, one permeable and one impermeable, are being kept under observation. The results so far show an increase in each case after a year's storage.

The Cracking of Heavy Soil.

Laboratory experiments have been carried out to determine some of the conditions under which cracking takes place. The nature and amount of clay present in the soil are governing factors, and the treatment of the soil prior to wetting is an important one. Blocks of soil were prepared by wetting, by draining centrifugally, kneaded by hand, and also treated with various salts. The general result showed that when the preliminary treatment led to a final density between 1·7 and 1·75 (as determined on the oven-dried sample), cracking took place; outside these limits cracking did not occur.

Investigations on Humus.

The results of the work carried out during the last five years may be summarized:

1. Sudan soils are low in organic matter, the total organic carbon being usually less than 1 per cent. In the Gezira the humus carbon is about 40 per cent. of the total.

2. Humus preparations purified as far as possible could not be obtained; ash-free specimens of humus from widely different sources contain nearly the same proportion of carbon.

3. Humus solutions (in very dilute alkali) keep fairly well in the dark and also in bright sunlight if air is excluded. For colorimetric purposes the use of standard solutions is justified if not kept too long.

4. Field studies show that the humus content of good soil is greater than that of poor soil.

5. There is a marked inverse connection between salt and humus content; this does not apply to depth distribution of these contents. In the Gezira the maximum humus content occurs at the fourth foot and the maximum salt content also runs at that depth.

6. The total nitrogen content of the soils studied is low, usually about 0·03 per cent. About one-fifth of this is humus nitrogen, and the carbon-nitrogen ratio is about twelve to one.

Experiments are now in progress dealing with the effect of temperature on the extract of humus by dilute alkali, as this is an important matter in the rapid estimation of humus by the colorimetric method. Preliminary experiments on thirty-two samples showed that 10 per cent. more humus (as measured colorimetrically) is extracted by hot alkali than by cold.

The Action of Alkalis on Clay and Silica.

In the presence of excess of neutral salt the amount of soluble clay compound formed is small provided that the concentration of

alkali used is such that the pH of the mixture is below nine. Under these conditions the amount of base absorbed appears to be independent of its nature, lithium, sodium, potassium, barium, and calcium giving substantially the same results. When the concentration of alkali causes the pH to be over nine, the amount of soluble compound increases until action appears to cease when ·002 gram equivalent of soluble sodium compounds have been formed per gram of clay.

Experiments on Flocculation.

Experiments with flocculating mixtures of sodium hydroxide and chloride have shown that the flocculating effect increases rapidly with increasing quantities of mixture added, then rapidly falls, and then increases again without any further diminution. The greatest amount of flocculent is required when the pH of the suspension is about nine. The phenomenon has been observed with different clays and only fails when the suspensions are alkaline. It is exhibited with mixtures in which the concentration of chloride ranges from 25 to 600 times that of the hydroxide, and can be observed with mixtures of calcium chloride and hydroxide where the concentration of the former varies from equality with to three times that of the latter. It is also shown with a more limited range of mixtures with kaolin, but here the concentration of the alkali must not exceed 1/250th of that of the chloride.

In observing these suspensions either with the naked eye or the nephelometer, a period of one hour has been found suitable.

As the soils of the Gezira have a pH value of about nine these results may turn out to be of importance in the field. The main points of these experiments on flocculation show that clay, kaolin, and "aluminated silica" resemble each other in their general behaviour towards flocculents and differ from silica, which is almost impossible to flocculate with acids and neutral salts.

The Electric Charge on Colloid Particles.

A theory explaining the electric charge on colloids is given in a paper published by H. B. Oakley, who has also suggested a method of measuring the charge on colloids.

Viscosity of Clay Suspensions.

The effect of alkalis and salts on the viscosity of a clay-water mixture is of interest in the study of heavy alkaline soils. It has

been shown that 10 per cent. suspensions of clay, with increasing concentrations of sodium hydroxide, show an increase in viscosity when the pH is between 8 and 10·5. With further addition of sodium hydroxide the viscosity at first decreases and then rises again to a higher value when sufficient alkali is added to flocculate the clay. Sodium carbonate does not show this maximum. When in addition sodium chloride is added in excess of the amount required to flocculate the clay the viscosity between pH values of 8 and 10·5 is many times greater than the viscosity at any other value of the pH. As the viscosity may be connected with important field properties, the fact that the maxima are obtained at pH values which are those of the Gezira soils is significant.

Apparent Variation of Salt Content on Drying.

Twenty-four samples of soil have been under examination for varying periods up to 345 days, samples being air-dried and oven-dried, and the following results obtained:

Time of Extraction.	*Salt Content from Conductivity Measurements.*			
	(1) *Air-Dried.*	(2) *Air-Dried: Corrected for Moisture Content.*	(3) *Oven-Dried.*	(4) *Percentage Increase* (1) to (3).
4 hours	0·322	0·352	0·452	40·3
18 „	0·415	0·453	0·496	19·5
7 days	0·471	0·515	0·510	8·5
18 „	0·501	0·547	0·527	5·2
77 „	0·573	0·625	0·582	1·6
139 „	0·539	0·591	0·549	1·8
345 „	0·576	0·627	0·582	1·0

The results in the last column show that after long extraction the conductivities of the extracts in air-dried and oven-dried samples are practically the same; on the other hand, if the air-dried results be corrected for the moisture content the amount of electrolyte in solution after seven days or longer is actually reduced by oven-drying. The conductances at 139 days were uniformly lower than at 77 days and rose slightly at 345 days; this fluctuation is probably due to temperature changes during storage. The question of variation in salt content in drying is of some importance, as it may bear on the changes taking place during the fallow period under arid tropical conditions.

Rate of Extraction of Electrolytes in Presence or Absence of Gypsum.

The following results are for determinations made after addition of water. For gypsum-free samples the eighteen-hours figures approximate to the zero time value, and for gypsum-bearing samples to their equilibrium values.

	Samples 1–6 (*Gypsum Free*).	*Samples* 7–9 (*Gypsum* 0·1 *per Cent.*).	*Samples* 10–12 (*Gypsum about* 3 *per Cent.*).
7 minutes	0·094	0·274	0·483
18 hours	0·104	0·554	0·899
345 days	0·252	0·674	1·127

Vertical Movement of Salts under Irrigation.

Twenty-eight plots representing over 2,000 samples have been examined at the end of the season. The results show, as in previous years, that the proportion of salts in the upper three feet is higher in the case of fallow than in the irrigated plots.

Condition of Land.	*Plot Numbers.*	*Ratio of Salts Upper to Lower.*	*Depth of Maximum below Surface (Inches).*
After irrigation ..	1, 6, 16, 18, 20, 23, 24, 25, 62, 66, 69, 70, 71, 72, 75	0·258	41·5
After fallow	8, 10, 14, 29, 30, 31, 33, 35, 38, 40, 42, 44, 45	0·298	38·5

In the case of four plots (Nos. 1, 16, 24, 25) which were under irrigation during the past two seasons (with, of course, a summer fallow in between), the second season's irrigation appears to have resulted in bringing an increased amount of salt to the surface. The mean result for the four plots was as follows:

	Salt Content.	*Ratio Upper to Lower.*	*Depth of Maximum (Inches).*
1924–25	0·272	0·216	46·6
1925–26	0·308	0·254	44·8

It is hoped to carry out further investigations on this important point if plots are available.

Depression of Salts by Irrigation after Fallow.

The depression of salts by irrigation after fallow is shown in the following mean results for Plots Nos. 6, 23, 62, 66, 69, 75, which were fallow in 1924–25 and irrigated during the past season.

	Salt Content.	*Ratio Upper to Lower.*	*Depth of Maximum (Inches).*
1924–25 (fallow)	0·335	0·371	36·5
1925–26 (irrigated) ..	0·300	0·243	42·0

Some of the salts appear to have been displaced below the sixth foot level; this requires further confirmation. Unexpected results were obtained from plots which were irrigated in 1924–25, and fallowed during the past season; in three out of four cases the fallow appeared to cause depression of salts. This is considered unlikely and is under further investigation.

Soil Inversion Experiment.

The salt gradient in the Gezira soil suggested that an experiment should be designed that would give some information as to the rate at which salt movement takes place.

A square 3 by 3 metres was excavated to a depth of six feet and the soil replaced, the soil taken at the top being placed at the bottom of the pit, foot by foot, until it was filled with inverted soil in this way. It was completed in February, 1925, and then given a normal watering every sixteen days. It was sampled on the dates shown below and the results for the salt determinations for the first four feet indicate a gradual conversion of the inverted soil into a normal one.

Date.	*Treatment.*	*Percentage of Salts.*			
		First Foot.	*Second Foot.*	*Third Foot.*	*Fourth Foot.*
1925:					
February ..	Before excavating (normal soil)	0·098	0·093	0·381	0·592
February ..	After inversion	0·546	0·464	0·592	0·381
April	After three waterings	0·504	0·623	0·652	0·381
October ..	After three waterings and rain	0·423	0·566	0·401	0·404
1926:					
April	After fourteen waterings and rain	0·121	0·369	0·398	0·396
September ..	After fifteen waterings and two season's rains	0·120	0·412	0·440	0·431

Relation Between Salt Content and Crop Yield.

Samples from good and bad plots were taken from four areas in the Gezira this year, and the mean result shows the usual relationship between salt content and crop yield, the average salt content for all the good plots being 0·163 per cent. and for the bad only 0·192 per cent. For the individual areas, however, the results are not uniform, as in two areas the salts in the bad plots were unusually low, being less than in the good plots, which are, however, as usual, low in salts.

	Wad el Attai.		*Kumour.*		*Abdel Hakam.*		*Medina.*	
	Good.	*Bad.*	*Good.*	*Bad.*	*Good.*	*Bad.*	*Good.*	*Bad.*
Number of plots ..	13	8	9	10	10	9	16	4
Yield	5·31	2·32	6·94	2·41	6·01	2·05	5·97	2·94
Salts (first foot) ..	0·087	0·091	0·080	0·104	0·093	0·095	0·092	0·088
Salts (first 4 feet) ..	0·168	0·221	0·145	0·222	0·187	0·155	0·156	0·146
Salts (all 6 feet) ..	0·218	0·245	0·212	0·322	0·247	0·258	0·218	0·205
Salts (first maximum)	4′ 0″	3′ 6″	4′ 6″	3′ 0″	4′ 6″	5′ 0″	4′ 6″	5′ 6″
Minimum	4′ 6″	5′ 0″	—	4′ 0″	—	—	—	—

Analysis of Field Observations.

These are necessarily qualitative in character, but nevertheless yield definite and informative results when subjected to suitable analysis.

Observations were made on (A) 60 six-foot holes in the Gezira Research Farm, 24 three-inch samples being taken from each hole, and (B) 64 six-foot holes in the canalized area, 12 six-inch samples being taken from each hole. In group A the number of occurrences of grey soil rises from 1 at step 10 to 49 at step 15, and falls again to 1 at step 22.

By using all the observations a precise estimate can be formed of (1) the depth at which grey soil is most commonly found and (2) its dispersion. By the term " dispersion " is meant the sharpness with which a change under study takes place. When the dispersion is large the change is gradual and *vice versa*. For the two groups the figures were as follows:

	A.		*B.*	
	Mean Depth (Inches).	*Dispersion.*	*Mean Depth (Inches).*	*Dispersion.*
Nut brown soil.. ..	41·7	10·2	45·7	12·5
Grey soil	44·6	6·6	49·3	13·6
Chalk patches	50·7	8·4	57·6	About 9

It will be observed that the same sequence of changes in soil character takes place in the two groups. Those of group B are lower and more dispersed than those of group A, or, in other words, the soil profile is more compact than that of B. This fact is related to the salt content since a six-foot column of soil A will contain a larger proportion of salty subsoil layers than a column of B of the same depth. Further work on these lines is being directed towards specifying soil types and ascertaining the distribution of reactive soil components whose resultant effect is measured in routine salt determinations.

Moisture Investigations. Drying Out after Rain.

These experiments, commenced in September, 1925, were continued until June, 1926, and indicate that the drying effect penetrates to a depth of 6 feet, but the water loss at this depth is very small.

Lateral Movement of Water on Land under Irrigation.

During irrigation the water is applied at the furrows, and it was necessary to determine whether the intervening 40 cms. of soil retarded the water to any appreciable extent. The figures below are for samples taken from adjacent ridges and furrows. Averages covering the irrigation cycle were:

	Furrow.	*Ridge.*
Top 18 inches	30·90	30·45 per cent.
Second 18 inches	20·95	21·12 „
Top 3 feet	25·92	25·78 „

Penetration of Irrigation Water.

Six subplots were examined throughout the irrigation cycle, and the results obtained indicate the slow penetration of the water. Samples were taken at depths of 6 inches, 1 foot 6 inches, and 3 feet 6 inches. The plots were sampled about two days after irrigation, and on six days at two-day intervals, 1,792 samples being taken. The figures show that the moisture content in the upper layer diminishes steadily with time, that water gradually penetrates the middle 18 inches in about six days and then is reduced, and that the lowest layer (3 feet 6 inches) is not affected by the amount of irrigation applied.

Depth.	*Moisture Content after*						
	Two Days.	*Four Days.*	*Six Days.*	*Eight Days.*	*Ten Days.*	*Twelve Days.*	*Fourteen Days.*
6 inches	37·0	36·1	36·5	33·0	34·8	32·5	31·5
1 foot 6 inches	21·7	23·9	24·7	21·4	23·0	21·3	21·4
3 feet 6 inches	20·5	21·6	20·8	19·9	20·8	20·5	20·6

A further experiment carried out on Plot 37 under cotton gave similar results, except that there was a slight indication of water penetration to the third foot. The samples in this case were taken every 6 inches, commencing towards the end of one irrigation cycle, and continued till the end of the next. The vertical line indicates the date of application of the water, and the figures underlined draw attention to the position of the maximum water content.

Depth.	*Moisture Content.*									
	October					*November*				
	21.	24.	26.	28.	31.	2.	4.	7.	9.	11.
0 to 6 ins.	29·0	26·1	23·6	43·6	35·2	34·8	28·9	25·6	23·1	21·4
1 ft. 0 ins. to 1 ft. 6 ins. ..	28·7	24·8	25·1	29·4	31·1	28·5	27·2	25·2	23·2	28·8
1 ft. 6 ins. to 2 ft. 0 ins. ..	22·0	22·4	22·5	23·3	21·7	22·8	24·5	22·9	21·8	21·1
2 ft. 6 ins. to 3 ft. ..	22·4	22·1	21·9	21·8	21·7	21·8	21·9	23·6	22·5	21·9
3 ft. 6 ins. to 4 ft. ..	24·6	25·4	24·0	24·0	24·7	24·7	24·5	25·4	24·7	24·5

The figures of the last horizontal line are practically constant, and the existence of the maximum shown in the 3-feet line requires confirmation.

Penetration of Water when Flooding follows Various Cultural Treatments.

Moisture investigations were carried out on subplots that had the following preliminary treatments before watering:

(1) Early ridging, November, 1925.
(2) Late ridging, July, 1926.
(3) Bastard trenching to a depth of 3 feet.
(4) Two waterings October and December, 1925.
(5) No treatment.

After fourteen days' flooding the plots were sown, lightly watered, and then sampled a month later.

The moisture results were as follows:

	Moisture Content (per Cent.).					
	One Foot.	*Two Feet.*	*Three Feet.*	*Four Feet.*	*Five Feet.*	*Six Feet.*
Treatment 1	25·0	32·0	30·8	27·9	23·8	22·3
„ 2	25·5	33·0	31·6	30·0	29·2	23·0
„ 3	24·1	30·5	34·3	33·1	34·0	30·7
„ 4	23·3	33·3	32·3	30·0	29·0	24·1
„ 5	21·3	32·8	31·2	29·5	26·6	22·6

The moisture percentage was highest with bastard trenching and lowest with early ridging.

The conclusion appears to be that in soils resembling the Gezira Research Farm an aid to water penetration would be afforded by adopting late ridging and very heavy initial watering. Whether root development is more advanced in this series of plots has yet to be ascertained.

Comparison Between the Amount of Irrigation Water Applied and that Found from Moisture Determinations.

In studying methods of applying irrigation water it is important to assess the amounts lost by evaporation and plant transpiration and that retained by the soil during the irrigation cycle and season: a necessary preliminary is to determine to what extent there is agreement between the irrigation water applied and that found by analysis.

On October 27 Plot 37 received a watering which was estimated at 430 tons per acre. Samples were taken on the following day and throughout the irrigation cycle. The figures given below for the average moisture content of all 6 feet are extracted from the results:

October 26	23·8 per cent.
„ 28	27·5 „
November 11	23·0 „

If we take an acre as weighing 10,000 tons the loss in fourteen days (4·5 per cent.) was 450 tons—*i.e.*, 32 tons a day. If the moisture content immediately before and after irrigation be assumed to be 23·8 – 0·32 and 27·5 + 0·32 respectively, the gain in irrigation becomes 3·7 + 0·64 = 4·34 per cent.—*i.e.*, 434 tons per acre, which is approximate to the above estimate.

Flooding Experiments.

An area of ten acres at Barakat was flooded from July, 1925, till February, 1926, when various crops were grown. Samples were taken on ten occasions, and the condensed results gave the following percentages for the moisture determinations:

Depths.	*Dates of Sampling.*			
	March 4.	*April* 8.	*May* 9.	*June* 17.
First foot	38·3	30·2	28·9	24·4
Sixth foot	32·7	34·1	30·9	29·6
Mean of all six feet	37·0	35·5	31·2	27·4

The results are of interest for the high moisture content which extends throughout the 6 feet.

The loss of water was 960 tons per acre for the whole period, or 9·2 tons a day, and this amount was sufficient for growing crops. If the detailed results be plotted against the date of sampling the curve shows a sharp rise at the middle of the period, due to the heavy demand made by the crop. The daily loss per acre for the first half was 4·4 tons, and the second half 13·4; if the rate of evaporation from the soil be assumed constant throughout the whole period, the difference of 9 tons a day, which is 67 per cent. of the total loss at that time, may be attributed to transpiration.

Further data were obtained by comparing water loss in Plot 37 under cotton with that of a 9-metre square close by. The latter was flooded from October 5 to 19, and took up water at the rate of 1,230 tons per feddan. Between October 25 and November 8 the square lost water equivalent to 130 tons per feddan—that is, 9·3 tons a day. At that time Plot 37 was losing 32 tons a day, of which at least 22·7 tons (*i.e.*, 71 per cent. of the total loss) may be attributed to transpiration.

If 70 per cent. be taken as an average figure, it is apparent that an acre of cotton receiving fifteen waterings of 400 tons transpires about 4,200 tons of water; previous experiments have shown that an average cotton crop under irrigation produces about 3 tons per acre of dry matter above ground—*i.e.*, 1,400 parts of water are required for the production of one part of dry matter, which is equivalent to about three times the requirements of ordinary crop plants given by Briggs and Shantz (United States Department of Agriculture Bureau of Plant Industry, Bulletin 284, 1913).

Apparent Specific Gravity of Soils.

To obtain information as to the closeness of packing of the soil, determinations of the apparent specific gravity were made by the waxed block method on samples of about 100 grammes of soil taken with a minimum of disturbance at some dozen depths to 4 feet in four holes at the Gezira Research Farm. The true specific gravity of dry soil was taken as 2·7. In the table on p. 92 the columns headed "density (wet)" and "density (dry)" give the average values of the weights in grammes of fresh soil and dried soil respectively of 1 c.c. of soil in its natural state in the field; moisture determinations were carried out in the same samples, and from the results the figures in the last three columns are calculated.

Depth in Inches.	*Density (Wet).*	*Density (Dry).*	*Percentage Composition by Volume.*		
			Soil.	*Water.*	*Air.*
(1) 0–6	1·64	1·32	49	32	20
(2) 6–17	1·66	1·26	47	41	13
(3) 17–18	1·71	1·31	49	39	12
(4) 18–24	1·75	1·37	51	37	11
(5) 24–30	1·77	1·44	53	33	14
(6) 30–36	1·81	1·49	55	32	13
(7) 36–42	1·77	1·44	53	33	14
(8) 42–48	1·75	1·41	52	33	14

From the figures for densities the following are calculated for the weight in tons of 1 acre foot of soil in the field.

	Wet Soil.	*Dry Soil.*
First foot	2,000	1,560
Second foot	2,090	1,620
Third foot	2,170	1,760
Fourth foot	2,130	1,730

There is a steady increase in the closeness of packing of the soil down to a high maximum value in the third foot corresponding with the observed hard layer in the soil profile at this depth.

Permeability of the Gezira Soil to Water.

The downward rate into uniformly packed 1 mm. samples of soil was determined for a series of samples from a 6 foot hole at the Gezira Research Farm. To eliminate irregularities during the addition of the water and relatively rapid movement during the first few minutes, the data quoted below give the amount of downward movement in centimetres in the interval between 10 and 1,000 minutes after adding the water.

Number of 6-inch layer	1	2	3	4	5	6	7	8	9	10	11	12
Water movement ..	8·0	5·8	4·0	3·5	2·1	2·6	7·6	6·5	4·6	6·3	5·2	7·9
Percentage of salts ..	0·08	0·09	0·09	0·10	0·12	0·14	0·52	0·64	0·50	0·90	0·97	0·83

The permeability to water falls off steadily from the surface to extremely low values in the third foot, and as this is the case even under uniform conditions of sieving and packing, the impermeability of the field soil at this depth must be an intrinsic property and would be intensified by the high density of the soil in the field. Below 3 feet the high salt contents increase the permeability by their flocculating action.

Rate of Capillary Rise.

This was observed in a soil sieved through a 1 mm. sieve and uniformly packed in glass tubes loosely closed by cotton-wool at the bottom. The figures below give the distance in centimetres wetted in the interval between 10 and 1,000 minutes for the series of experiments.

(*a*) Comparison between eight successive 6-inch layers from a good and a bad soil not widely separated and having given cotton yields of 3·4 and 1·4 kantars per feddan in the preceding season.

Number of 6-inch layer ..	1	2	3	4	5	6	7	8
Capillary rise in good soil ..	11·9	5·5	3·5	4·9	3·3	2·3	5·1	2·7
„ „ in bad soil ..	7·6	3·3	3·0	2·7	4·4	5·3	4·0	3·9
Percentage salts in good soil ..	0·05	0·08	0·08	0·08	0·09	0·13	0·41	0·38
„ „ in bad soil ..	0·07	0·11	0·12	0·26	0·49	0·42	0·39	0·41

The good soil gave the more rapid movement in the first 2 feet, and the slower movement in the third and fourth feet corresponding with its lower contents of deflocculating salts (sodium carbonate) in the upper layers and of flocculating salts (sodium sulphate) in the lower layers.

The depths of lowest capillary rise are 33 inches for the good soil and 21 inches for the bad soil. These are also the depths at which the first marked increase in salt content occurs, and are 6 inches above the first maximum salt content.

(*b*) Mean values of a series of seven good and six bad soils with yields of 3·5 and 1·6 kantars per feddan respectively, and salt contents in the first foot of 0·066 per cent. and 0·084 per cent.

Number of 6-inch layer	1	2	3	4	Mean
Capillary rise in good soil	9·2	8·2	5·6	4·4	6·8
„ „ in bad soil	5·3	3·8	3·8	3·4	4·1

There is a general parallelism between high yields, low salts, and rapid water movement. The differences of water movements are more marked in the surface layers than at 2 feet. This method is now being applied to the examination of large numbers of samples with a view to supplementing salt determinations in the rapid characterization of soils. It has the advantage of giving some measure of a factor of direct practical importance.

The Nitrate Content in the Gezira.

For previous records on nitrification in Sudan soils *vide* Bulletin No. 29, July, 1923.

Experiments are now in progress which follow the nitrate content of fields under various treatments throughout the season. Each plot or subplot under examination is sampled to 1 foot in eight places and the samples mixed. Nitrate determinations are then carried out on this composite sample in duplicate.

The results given below are from fields growing cotton last year (C) and dura this year (D). The results are averaged from strips which received no manure (Plots 69–72) and from strips receiving an average of 250 lbs. of sulphate of ammonia (Plot 74). The manure was applied in August, 1925, before the sampling commenced. The results are given in parts per million of NO_3.

	Nov.	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*April.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*
Crop ..	C	C	C	C	C	C	—	—	—	D	D	D
No manure	23	24	43	55	79	68	21	13	21	12	8	9
Manure ..	64	52	99	211	259	247	118	23	22	26	10	8

The manured plot certainly contained much more nitrate in the season 1925–26; during the fallow the nitrate, as usual, falls to a low figure, and remains low at the beginning of the next season owing to the demand of the dura crop.

Influence of Moisture Content of Soil on Nitrification.

It has been previously shown that the nitrate content of samples of soil stored in the laboratory alters rapidly (*vide* Bulletin No. 29). Further experiments have shown the importance of the moisture content of the soil as a factor in this change.

Samples of Gezira Research Farm soil with moisture contents of 10, 20, 30, and 40 per cent., with additions to various series of twenty-seven parts per million (p.p.m.) of nitrogen as sodium nitrate and ammonium sulphate were stored. One-half of the series received 0·1 per cent. of organic matter in the form of ground-up cotton roots. At four intervals during six weeks nitrate and nitrite determinations were made.

Untreated soil at each moisture content showed a slight decrease in nitrate content from an initial value of six p.p.m. nitric nitrogen. Nitrification of the added ammonia was almost complete in six weeks at 30 and 40 per cent. moisture content, but no nitrification took

place at 10 and 20 per cent. moisture content. The addition of organic matter reduced the nitrate contents in all cases except the driest. In soil receiving organic matter but no added nitrogen, the nitric nitrogen fell to one p.p.m. or less in six weeks. Relatively large amounts of nitrous nitrogen up to four p.p.m. were found in all soils at 20 per cent. moisture content, and in the 30 per cent. sample which had received ammonium sulphate.

A moisture content of 20 per cent. thus acts differentially on *nitrosomonas* and *nitrobacter*, and allows an accumulation of nitrite such as never occurs in normal soils.

Such nitrite formation in relatively dry soils may lead to a loss of nitrogen from the soil.

Date of Application of Ammonium Sulphate to Cotton.

Experiments previously recorded were repeated on Hosh 10 at Shambat. Although the experiment was unsatisfactory for several reasons, it is felt advisable to record it. Thirty $\frac{1}{10}$-acre plots were used, of which five were controls. The cotton (Sakellarides) was sown on June 1, 1925, a fortnight earlier than in the previous trial. Two hundredweights of ammonium sulphate were applied at various dates with the following results:

Time of Application.	*Yield in Lbs. Seed Cotton per Acre.*	*Per Cent. Increase.*
No manure	722	—
At sowing	760	5
50 days after sowing	724	—
75 „ „	736	2
100 „ „	626	—
125 „ „	672	—

The results were unsatisfactory; the plot used was bad land, and a lubia crop had been ploughed in during April in connection with another experiment; this appears to have had an adverse effect on the land, a phenomenon which has been previously observed. In another trial, recorded below, in connection with another experiment, 2 cwts. of ammonium sulphate were applied to Hosh 2 twenty-one days after sowing; the result showed 808 lbs. seed cotton in the controls and 864 lbs. for the manured plots, an increase of 6½ per cent.

Seasonal Variation of Nitrate Content.

The five control plots referred to in the last paragraph were examined twenty-three times during the season for nitrate content; the influence of the lubia crop ploughed in was reflected in the

higher proportion of nitrates. As a rule, two sets of samples were taken each month, and the results given below represent the average of these.

	May.	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*
1924–25	—	17	128	81	99	179	266	81	81	53	118
1925–26	73	291	143	110	170	124	114	145	203	124	139

Effect of Gypsum on the Cotton Crop.

Experiments were continued on Hosh 2, five $\frac{1}{10}$-acre plots being used as controls, and five had gypsum at the rate of 1 ton per acre, and five others at the rate of 2 tons per acre. The gypsum was applied to the land on May 15, 1925, and the cotton sown on June 2. The results were somewhat inconclusive.

No gypsum yielded 1,332 lbs. seed cotton per acre.
1 ton gypsum yielded 1,482 „ „ „
2 tons gypsum yielded 1,332 „ „ „

Comparison between Calcium Cyanamide and Ammonium Sulphate.

A short trial was carried out at Shambat to compare the efficiency of these two fertilizers.

Five plots each $\frac{1}{10}$ acre were used as controls and five for the ammonium sulphate (2 cwts. per acre applied twenty-one days after sowing) and five for the cyanamide (2 cwts. applied at sowing). The results of the application of calcium cyanamide were disappointing, and rather indicate that it is not a suitable fertilizer for alkaline soils.

Controls: 808 lbs. seed cotton per acre.
Ammonium sulphate: 864 lbs. seed cotton per acre.
Calcium cyanamide: 812 „ „ „

Sulphur as a Fertilizer.

Field trials at Shambat in which five small plots of $\frac{1}{24}$ acre each were treated with sulphur at the rate of 1 ton per acre were carried out, five similar plots being used as controls. Cotton was sown on June 6, 1925, and the results were as follows:

	Controls.	*Sulphur Plots.*
pH before the trial	8·78	8·60
pH after the trial	8·84	8·28
Soluble salts after trial, first foot samples	0·089	0·361
Yield in lbs. of cottonseed	869	936

The results showed a slight increase of yield, reduced alkalinity, and increase in the water-soluble salts. Further investigations are necessary to ascertain the ultimate combined effect of reduced alkalinity and increase of water-soluble salts.

The Effect of Gypsum on the Permeability of Water.

This trial followed a laboratory experiment in which the permeability of Gezira soil was shown to be greatly increased by the application of gypsum. Thus in one case the capillary rise was increased from 25 to 81 mm. by treatment with gypsum solution.

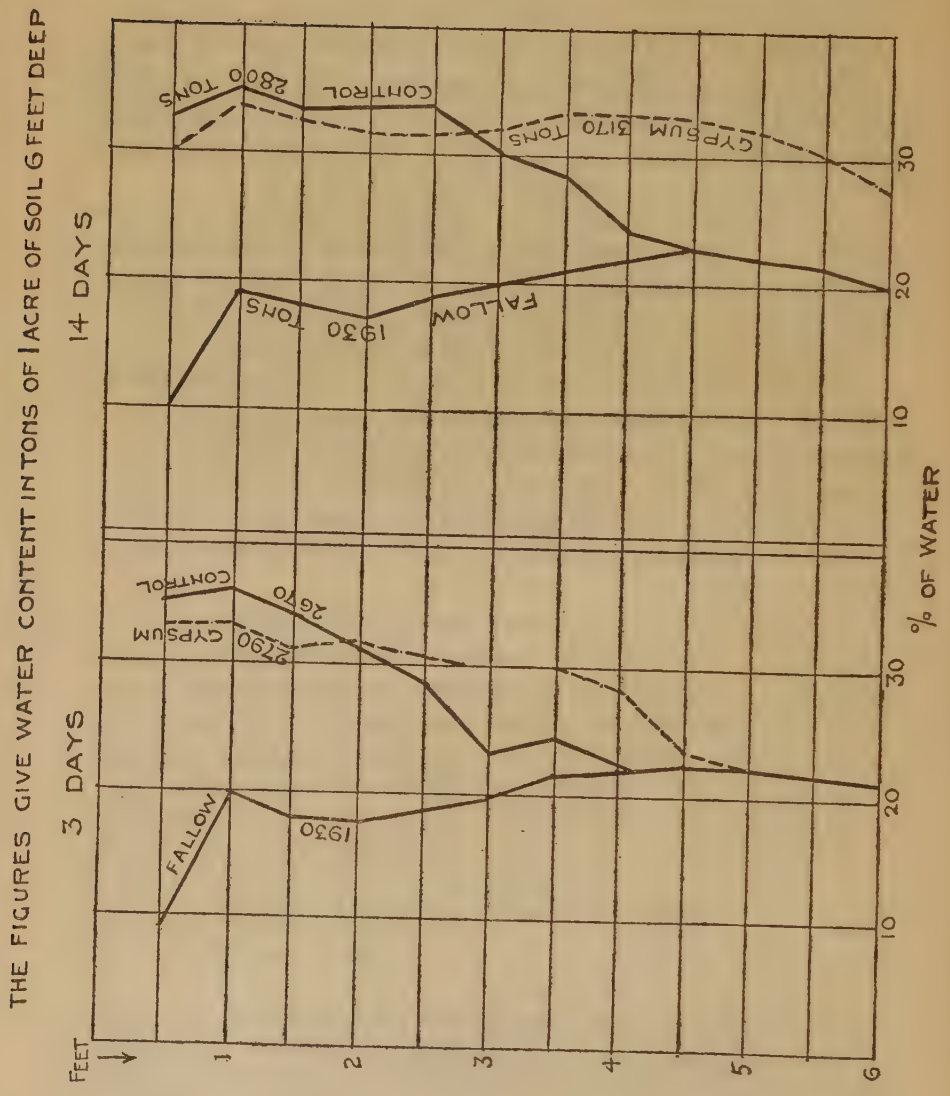
The field trial consisted of flooding a number of 9-metre squares for three, seven, fourteen, and twenty-one days with and without the addition of gypsum, samples being taken for moisture determinations as soon as possible after the flooding was concluded. The gypsum was applied at the rate of 10 tons per feddan.

The following table shows the amount of water taken up by the soil and its distribution; not only is the former increased in each case, but what is more important a satisfactory distribution was obtained by the use of gypsum. In the table the second column gives the average moisture content of the sixteen plots at depths to 6 feet before flooding; the remaining columns give the results after the various floodings.

Depth of Sample (Feet).	*Before Flooding (per Cent.).*	*Three Days.*		*Seven Days.*		*Fourteen Days.*		*Twenty-one Days.*	
		Gypsum.	*Control.*	*Gypsum.*	*Control.*	*Gypsum.*	*Control.*	*Gypsum.*	*Control.*
1	13·8	32·3	35·6	31·4	34·0	31·5	33·5	29·7	30·3
2	17·9	31·1	32·1	31·5	32·3	31·9	33·4	31·5	35·1
3	18·8	30·2	25·9	32·3	25·9	31·5	31·9	32·7	33·1
4	21·6	29·0	23·0	32·5	22·3	33·3	26·2	33·2	37·3
5	22·1	22·8	22·2	29·8	23·1	32·7	21·9	32·0	32·3
6	21·3	21·5	21·4	25·0	21·7	29·1	21·0	30·5	21·7
Mean ..	19·3	27·8	26·7	30·4	26·6	31·7	28·0	31·6	28·3
Water taken up		8·6	7·4	11·1	7·3	12·4	8·7	12·3	9·0

The amount of water taken up was increased about 16 per cent. in the case of three days' flooding and about 30 per cent. in the others. The penetration of the water is greater in all cases, producing an effect noticeable to a depth of 5 or 6 feet. On this land the improvement caused by extending the flooding from fourteen to twenty-one days was small.

The attached graph shows the relationship for the three and fourteen days' experiments.


THE FIGURES GIVE WATER CONTENT IN TONS OF 1 ACRE OF SOIL 6 FEET DEEP
14 DAYS
3 DAYS
CONTROL
2800 TONS
GYPSUM 3170 TONS
FALLOW
1930 TONS
CONTROL
2690
GYPSUM
2670
FALLOW
1930
FEET
1
2
3
4
5
6
10
20
30
% OF WATER

Flooding Experiments on Land in the Northern Gezira.

These experiments were carried out at Meilig (kilo. 91), Abu Ushar (kilo. 106), and Ganib (kilo. 118), and consisted of flooding small plots, which were treated as follows:

1. Ridged and watered twice with an interval of fifteen days.
2. Flat watered twice with an interval of fifteen days.
3. Flat and flooded for fifteen days.
4. Flat and flooded for thirty days.

The moisture content of the land before flooding was inferred from the examination of holes dug at the corners of the plots, and the plots were sampled as soon as possible after flooding.

The results are summarized in the following table, which shows the increase of moisture content resulting from the treatment averaged for a depth of 6 feet, and also the depth to which the penetration had reached.

	Meilig.	*Abu Ushar.*	*Ganib.*
Salt content of soil first 3 feet	·534	·125	·411
Water absorbed (tons per feddan):			
Flat, and watered twice	230	680	440
Ridged, and watered twice	520	870	740
Flat, and flooded fifteen days	910	1,860	520
Flat, and flooded thirty days	680	2,810	1,280
Depth of penetration after thirty days ..	2 feet	6 feet	2 feet

The difference between the behaviour of the soil at Abu Ushar (good land) and that of Meilig and Ganib is very striking.

The Effect of Gypsum on Land showing Low Permeability to Water.

This experiment was carried out at Ganib, where a previous investigation of the land had shown that the permeability to water was poor. The gypsum was applied at the rate of 1, 4, 10 tons per feddan. The following table shows the moisture content of the soil after fourteen days' flooding:

Percentage of Moisture in Soil.

Depth in Feet.	*Fallow.*	*No Gypsum.*	*One Ton.*	*Four Tons.*	*Ten Tons.*
1	7·7	31·9	31·2	30·3	30·0
2	11·5	21·4	30·9	33·1	33·4
3	14·8	14·4	20·7	32·1	32·8
4	14·4	14·5	14·5	23·3	30·2
5	14·0	14·0	13·6	13·9	17·3
6	14·5	13·9	12·8	13·5	14·3
Mean	12·8	18·3	20·6	24·4	26·3
Uptake of water (tons per feddan)	—	550	780	1,160	1,350

Further experiments will be carried out to determine the best method of application of the gypsum and the extent to which the beneficial effect will be permanent. A chart illustrating the experiments mentioned in the last two paragraphs is attached.

Soil Survey of the Northern Gezira.

The object of this survey was the examination of an area about 270,000 feddans immediately to the north of the 300,000 feddan area already canalized. For this purpose 240 holes were dug to a depth of 5 to 6 feet, of which eighty-two were selected for complete examination, being as far as possible two minutes apart on the map, a number of others being submitted to partial analysis.

The average of these results is given below, together with those for the 300,000 feddans and for Blocks 18 and 19 (Nidyana and Wad Sulfab), which are the most northerly of the canalized area.

	Clay (First Foot).	*Salts (3 Feet).*	*Humus (First Foot).*	*Depth at which Grey Subsoil Appears.*
The 300,000 area ..	52·9	0·175	235	3·7 feet (Central Area).
Blocks 18 and 19 ..	48·7	0·213	195	2·8
Northern extension ..	44·6	0·271	158	2·6

These figures indicate a progressive change in the Gezira plain from north to south, characterized by increasing proportions of clay and organic matter and diminishing amounts of salts and sodium carbonate (alkalinity). The grey or blue-grey subsoil, which is a regular feature of the whole plain, dips further below the surface towards the south, the upper layer of brown with its lower portion of somewhat impermeable soil being shallower in the north. The chemical composition of the readily soluble salts appears to be the same over the whole of the eastern plain. In the upper layers they consist almost entirely of sodium carbonate, and in the lower of sodium sulphate. The latter constitutes 90 per cent. or more of the white encrustations so often seen on the surface of irrigated land, and in places where seepage has taken place through canal banks.

Compared with the 300,000 feddans already canalized, the northern area investigated appears to be lighter in texture, contains 50 per cent. more salts and 30 per cent. less humus, and the grey soil is nearer the surface. Comparisons between the salts in the 300,000 feddan area and the northern area shows the following percentages:

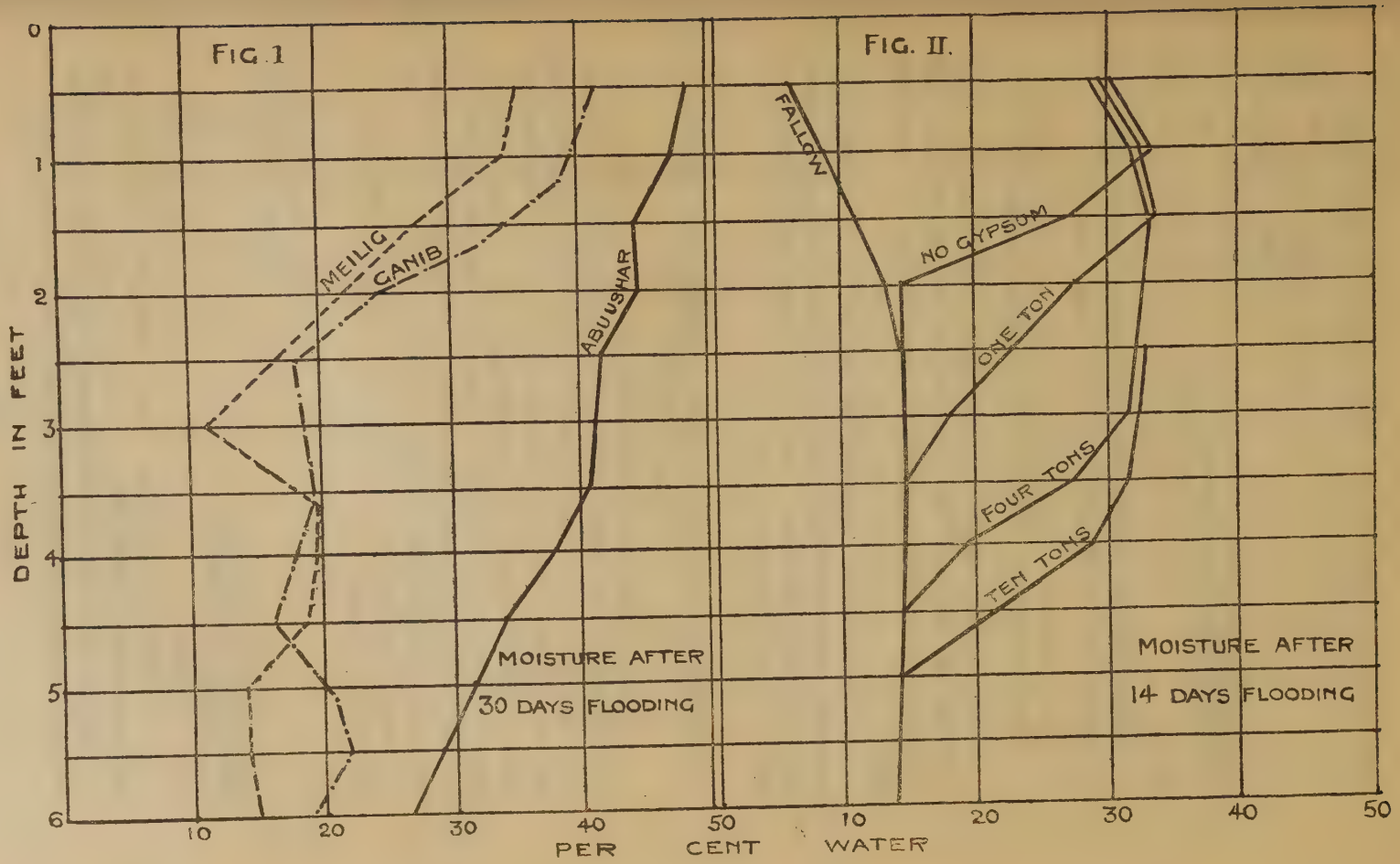


FIG. 1
FIG. II.
DEPTH IN FEET
0
1
2
3
4
5
6
MEILIG
CANIB
ABU USHAR
MOISTURE AFTER
30 DAYS FLOODING
FALLOW
NO GYPSUM
ONE TON
FOUR TONS
TEN TONS
MOISTURE AFTER
14 DAYS FLOODING
10
20
30
40
50
PER CENT WATER

	300,000 *Feddans* (*per Cent.*).	*Northern Area* (*per Cent.*).
Percentage of area with salt below 0·2	71	27
„ „ „ between 0·2 and 0·3..	24	39
„ „ „ above 0·3	5	34

Twenty-two first-foot samples in the northern area were examined for tendency to waterlogging with the following results:

Twelve satisfactory samples showed average alkalinity 9·36.
Ten waterlogging samples showed average alkalinity 9·60.

A few determinations of total nitrogen gave 0·021 per cent. in the northern area, compared with 0·029 per cent. in the unirrigated part of Blocks 18 and 19 near good land, and 0·024 per cent. near bad land.

For further details regarding the analysis of the various holes examined, reference should be made to the Report on the Soil Survey of the Northern Extension of the Gezira Scheme, dated February 15, 1927, by the Government Chemist.

Résumé of the Investigations on Gezira Soils for the Season 1926–27.

(*a*) *Relation Between Soil Characteristics and Crop Yield.*—Detailed operations on "soil profile"—*i.e.*, the nature and thickness of the different zones when a vertical wall of soil is exposed—have proved of value. These zones comprise: (*a*) Upper brown zone containing sodium carbonate; (*b*) a middle grey zone containing sodium sulphate; (*c*) a brown zone with gypsum crystals. In land of poor fertility the zones lie closer to the surface—*i.e.*, the soil profile is more compact in bad land than in good.

Results obtained from sixty-one good plots and sixty-one bad plots were as follows:

	Good Plots (*Inches*).	*Bad Plots* (*Inches*).
Grey soil begins at a depth of	48	45
Percentage of salts reaches 0·3 at	37	33
Gypsum first seen at	33	27

(*b*) *Soil Survey of the Gezira.*—Map I. indicates the soil survey of the Gezira up to June 30, 1927.

Maps II., III., and IV. show roughly the salt content of holes two minutes apart. The 300,000 feddans already canalized are much

better in this respect than the land lying to the north and west, and on the whole the tendency is for the salts to increase in those two directions. Some of the land in the northern area to be irrigated in the coming season is high in salts, and the results will be specially interesting, though it may not be till the second irrigation season that the most important effects are exhibited.

(*c*) *Penetration of Water.*—This appears to depend on the nature of the base combined with the clay; when it is lime or potash the permeability properties are excellent, but where the clay is in combination with soda a condition of impermeability always results, unless the clay be flocculated. This is illustrated by the following figures, giving the capillary rise in five hours for samples of the same soil washed with (*a*) sodium chloride, (*b*) potassium chloride, (*c*) calcium chloride, the treatment being followed by washing with water to imitate irrigation. The results were:

Original soil, 33 mm. rise in five hours.
Treated with sodium chloride, 3 mm. rise in five hours.
Treated with calcium chloride, 152 mm. rise in five hours.
Treated with potassium chloride, 195 mm. rise in five hours.

(*d*) *Ameliorating Effect of Gypsum in Salty Land.*—The effect of gypsum is to obliterate to a considerable extent the refractory nature of the soil as judged by the results at Ganib, where penetration to a depth of 5 feet was obtained after fourteen days' flooding.

(*e*) *Movement of Salt under Irrigation.*—The main points resulting from the records of three seasons are as follows:

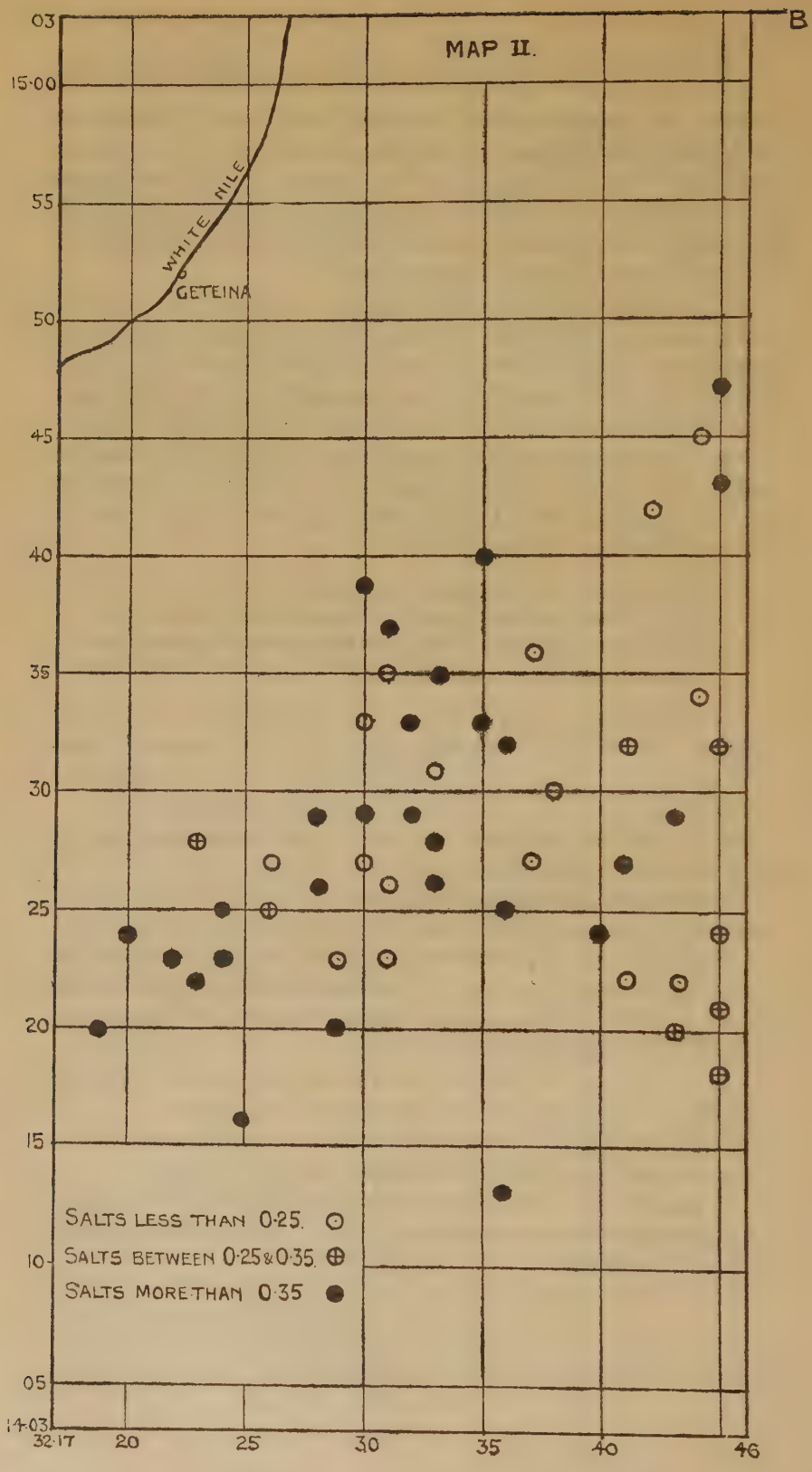
(1) During the fortnightly irrigation cycle there is a slight upward movement of salt during the second half or drying period of the cycle.

(2) When fallow land comes under irrigation there is a downward movement of salts. As regards total salt content, however, conflicting results have been obtained, for this was reduced by irrigation in 1925–26, and increased in 1926–27.

(3) An increase in total salt content and an upward movement take place in plots irrigated for two consecutive seasons.

(4) Fallow following irrigation is accompanied by a marked reduction in the ratio of salts in the upper and lower 3 feet.

An experiment is being planned for a small plot to be kept fallow for a number of consecutive seasons with a view to obtaining more data on this question.


MAP II.
B
WHITE NILE
GETEINA
SALTS LESS THAN 0·25.
SALTS BETWEEN 0·25 & 0·35.
SALTS MORE THAN 0·35
03
15·00
55
50
45
40
35
30
25
20
15
10
05
14·03
32·17
20
25
30
35
40
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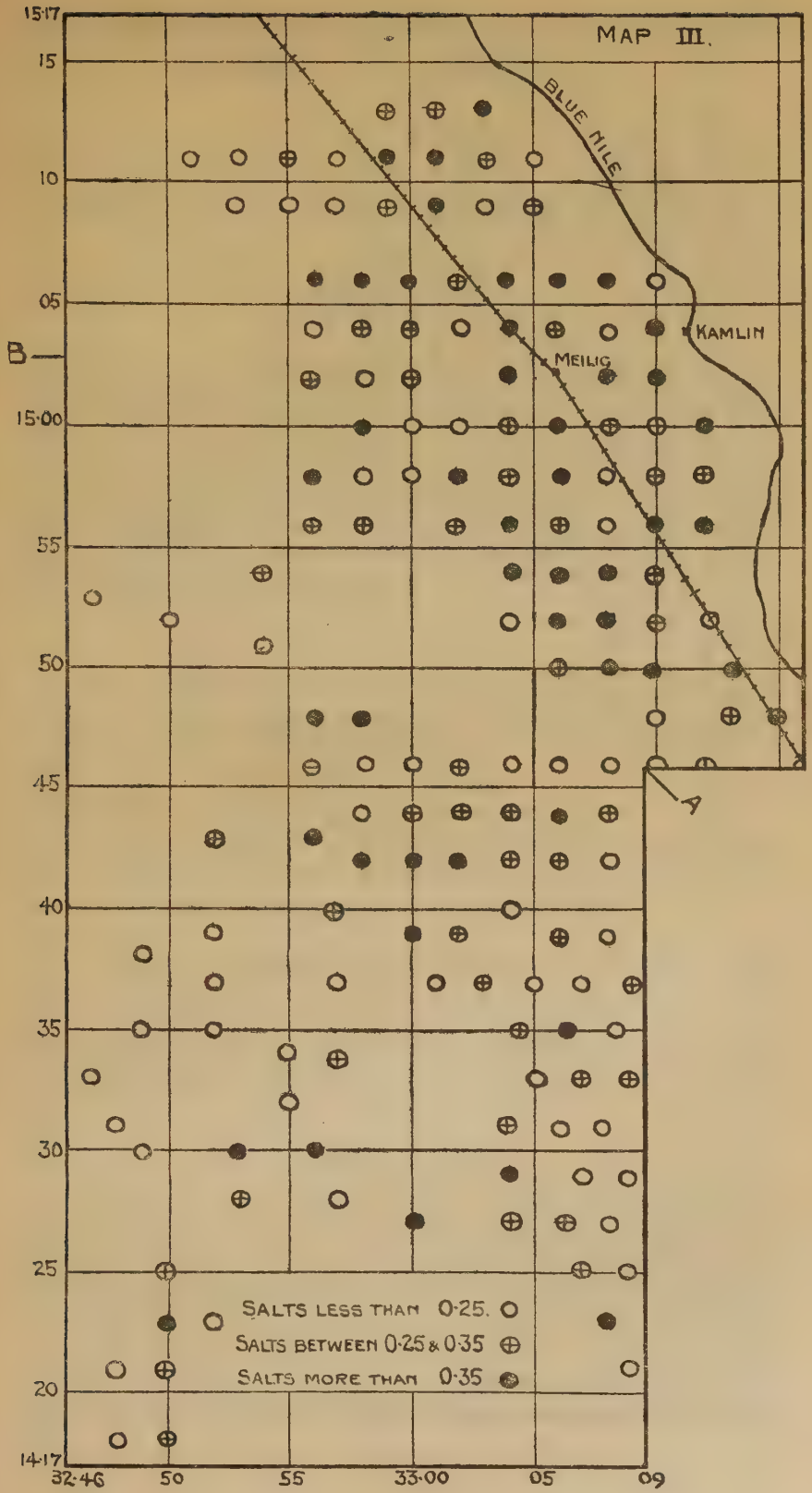
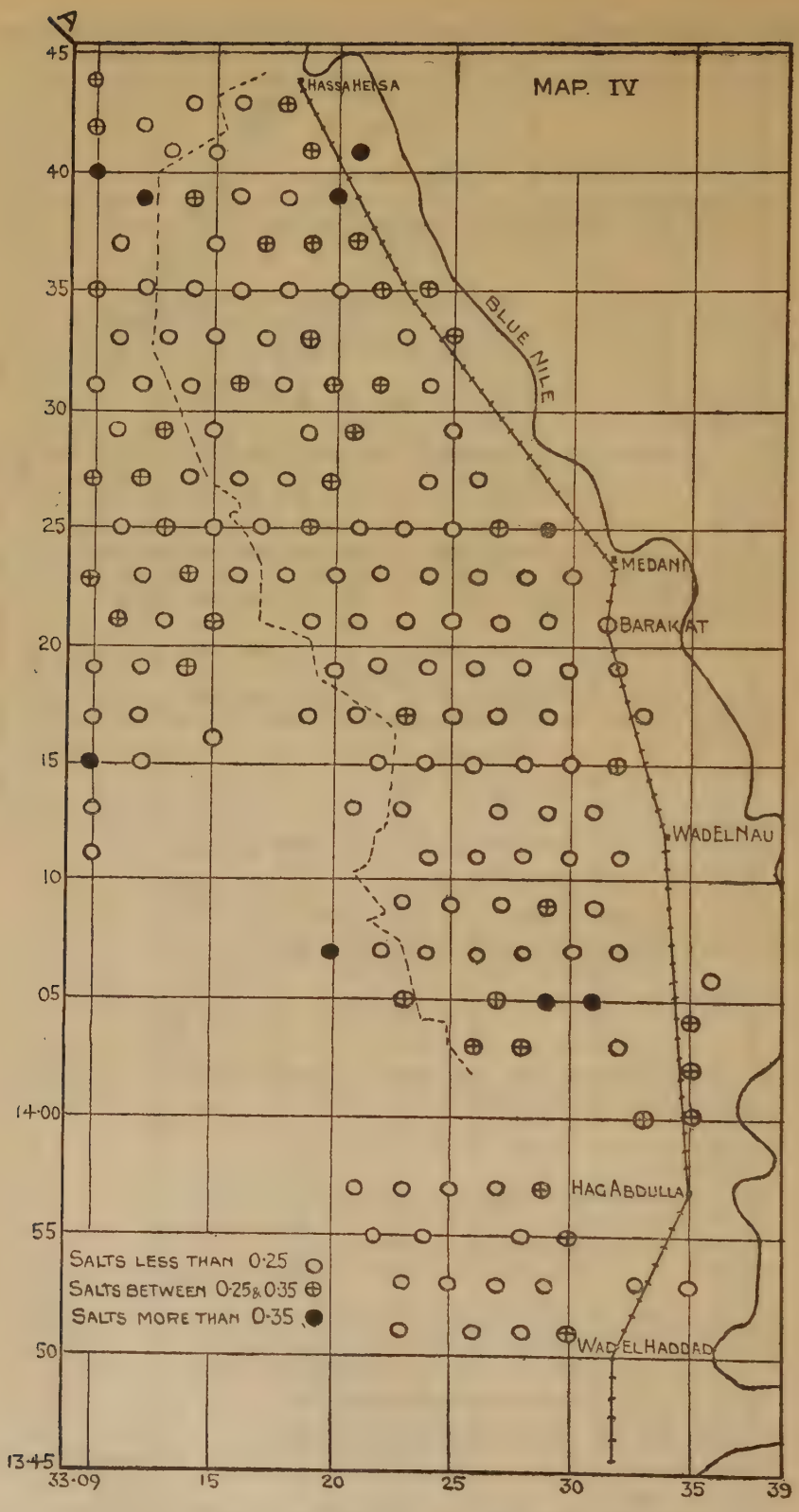

MAP III.
BLUE NILE
KAMLIN
MEILIG
A
B
SALTS LESS THAN 0·25.
SALTS BETWEEN 0·25 & 0·35
SALTS MORE THAN 0·35
15·17
15
10
05
15·00
55
50
45
40
35
30
25
20
14·17
32·46
50
55
33·00
05
09


MAP. IV
HASSAHEISA
BLUE NILE
MEDANI
BARAKAT
WADELNAU
HAG ABDULLA
WAD EL HADDAD
SALTS LESS THAN 0·25
SALTS BETWEEN 0·25 & 0·35
SALTS MORE THAN 0·35
45
40
35
30
25
20
15
10
05
14·00
55
50
13·45
33·09
15
20
25
30
35
39

WORK OF THE ENTOMOLOGICAL SECTION

BY

H. H. KING,

Government Entomologist.

Since the commencement of the year the research work has been reorganized and placed under the supervision of Mr. H. B. Johnston vice Mr. Bedford, who returned for special duties at Khartoum. Mr. Bedford's work since the inception of the laboratory in the Gezira has been invaluable, and his demonstrations, both in the laboratory and in the field, have been much appreciated, and have led to a satisfactory liaison between the Entomological Section and the staff of the Sudan Plantations Syndicate.

Exhibit.

An exhibit showing the pests and diseases of crops grown on the Gezira is nearing completion, and should prove useful for demonstrations to the members of the Syndicate.

Pest Incidence and Disease.

Records in considerable detail have been compiled by Mr. Bedford showing agricultural methods, dates of sowing, incidence of pests and disease, and ultimate yields of the various irrigated areas.

Control of Pink Bollworm (*Pectinophora gossypiella*).

The sunning of cottonseed to control this important pest has now become an operation of considerable magnitude. At the Barakat ginneries nearly 20,000 ardebs, approximately 1,800 tons of seed, were sunned under the supervision of Mr. Bedford.

Research Work.

Investigations have been carried out on the bionomics of the Cotton Thrips (*Heliothrips indicus*), Flea-beetle (*Nisotra uniformis*), Stem-borer (*Sphenoptera gossypii*), Stainer Bug (*Dsydercus superstitiosus*), Locusts, and various species of Termites, and a special study is being made of the Pink Bollworm attacking cotton in the Gezira.

Mr. Johnston has taken up the study of the parasitization of the pests of cotton and other plants as a possible means of control. His researches have already demonstrated the existence of a parasitic

hymenopteron for the Cotton Stem-borer (*Sphenoptera gossypii*), for the dura and dukhn plant bug, and for the sunt caterpillar. The parasite attacking the Cotton Stem-borer is a Chalcid, and has been identified by Waterston as a species of the genus *Lathromeris*; it attacks its host only in the egg stage. Its distribution as well as its habits have been studied, and there would appear to be a definite possibility of the employment of *Lathromeris* for the successful control of the stem-borer. The possible parasitization of the Pink Bollworm has been considered, and experiments are being carried out with a Braconid (*Microbracon hebetor*, Say.), which is a parasite for the moth *Corcyra cephalonica*, a common pest of stored seeds in the Sudan. At Suakin last year *Microbracon* proved a useful parasite for *Corcyra*.

From the investigations so far carried out the parasitization of insect pests in the Gezira as a means of control affords great possibilities for useful research.

The following papers were published:

" A Note on Locusts." By H. B. Johnston.

" A Simple Form of Distributor for Insecticide Dusts." By H. H. King and H. B. Johnston.

PEST REPORT FOR THE GEZIRA RESEARCH FARM FOR THE SEASON 1926-27

BY

H. B. JOHNSTON,

Senior Entomologist at the Farm.

The following deals as briefly as possible with the main pests observed on the Farm during the season 1926–27.

1. Thrips.

The infestation showed a general spread at the commencement of the season, and later a greater localization of the attack, which ceased almost entirely at the end of March.

This is seen clearly from the following notes, which show the progress of the infestation:

August 30.—Adult Thrips noticed on seedling cotton. Present in small numbers, but distribution general. Early appearance due probably to lack of rain.

September.—Thrips controlled by late rains. Little damage to end of September, present on seedling cotton, and, to a slight extent, on the lower leaves of older plants.

October.—Thrips on the increase. Most damage to late-sown cotton, but spreading to older plants, as well as to lubia, etc. The attack has spread almost throughout the older cotton, the insects feeding on the lower leaves and moving up the plants. No considerable damage so far. By end of the month the attack was chiefly conspicuous on plants somewhat isolated and along the north side of plots.

November.—Thrips continue to increase. Late-sown cotton heaviest infested.

December.—Thrips not very active, damage slight. Western edges attacked, eastern edges free, due to abusittas on the east side causing unfavourable conditions. Attack along the north side not noticeable except where Ads screen is broken. Plants on the east side are green and stronger than those further in the field, and Thrips have not spread inwards to the cotton on the lower level, which has suffered more from climatic changes.

January.—Increased damage by Thrips, but rather local and confined to certain stages of growth. Healthiest plants affected—*i.e.*, the late maturing cotton and that on the higher ridges. In places plants very heavily affected, leaves, bracts, and bolls. Resowing badly attacked, whereas originals free. Cotton plots on the north side of Farm have escaped attack.

February.—Damage by Thrips more common, but local, causing leaf-shedding. The later sowings badly affected. Variety plots have suffered. The manurial trial and spacing plots have suffered chiefly along the eastern and western side, especially the former.

March.—Damage decreasing. Increased plant growth. Thrips very few.

April.—Thrips almost disappeared except in stronger growth.

2. Termites.

Damage by Termites to the Farm cotton commenced at the very beginning of September, and most of the wilting of cotton during this period was due to Termite attack, neither Stem-borer nor Cotton Wilt making itself felt at this date. Termite attack during October increased very slightly, and again during November a slight increase was noted; but from then onwards until the last Farm Pest Report for the 1925–26 season was made in April, the Termite attack remained practically constant at the figure of 0·4 per cent. of certain observed areas, and indeed remained thus until the end of April, when it began to decrease. The Termite in question was the small Cotton Termite in every case. During November and for a period of about six weeks both the large Termite and the small species attacked lubia, and caused quite an appreciable damage in certain localities; this attack ceased suddenly about the middle of December.

From December onwards the large Termite caused considerable

damage to the Ads screens at the south sides of the various Farm plots, and continued doing so until the end of February, every plant attacked nearly always dying.

It is interesting to note that of the three crops grown (cotton-lubia-dura), and also Ads screens, cotton was attacked only by the small Termites, lubia by both the small and the large species. Dura, when it had been cut down and there remained a green stump only, was attacked by the large Termite. The Ads screens were heavily attacked by the large species.

3. Stem-Borer and Cotton Wilt.

The most notable points about Stem-borer attack were that, as the season advanced and the cotton grew older and stronger, less and less plants were killed by the attack; whereas Cotton Wilt continued in about the same proportion, killing all plants it attacked.

The monthly percentages of attack, computed from decreasing totals from observed rows, were as follows:

	Stem-Borer.	*Cotton Wilt.*
October	0·5	0·15
November	0·5	0·04
December	0·5	0·08
January	0·4	0·08
February	0·4	0·09
March	0·4	0·1

The average percentage attack for the season being—

Stem-borer	0·45
Cotton Wilt	0·09

An interesting point noticed during the season was that Termite attack followed fairly frequently upon Stem-borer attack, but very rarely upon Cotton Wilt. Also, after a little practice, it became possible in many cases to differentiate between a cotton plant wilting from Stem-borer and from Cotton Wilt: in the former case the apical leaves only wilting at first, the symptoms spreading gradually downwards over the whole plant; while in the latter case it was very difficult to tell Cotton Wilt attack from simple heat wilt at midday, the whole plant becoming flaccid and weak.

4. Cotton Flea-Beetle.

The damage done to seedling cotton at the beginning of the season was light. In November and December attack was observable in certain plots, and particularly in the case of plants on the higher ridges. This was followed later in March and April by a marked increase in plots drying off.

5. Blackarm.

Taken generally the attack showed a regular increase from August till February, after which month a steady decline took place. In August young cotton showed both leaf and stem infection. This was higher in the early-sown plots. Stem lesions were particularly noticed in the Tokar seed plots. These forms of attack increased during September and October, and the infestation became more general, early-sown cotton suffering most markedly. At this stage little difference could be observed between the various types of experimental cotton with respect to presence of Blackarm, except that Gezira seed plots seemed to suffer most. Later in the season the general healthier condition of the manurial trial plots was evident. Indirectly it is not improbable that this treatment diminished the amount of Blackarm infection on these plots.

6. Cotton Bollworms.

(*a*) *Pink Bollworm.*—This was not found in samples of bolls from the Farm during January. It appeared during February in 3·6 per cent. of bolls examined. This figure was not exceeded during the remainder of the season.

(*b*) *Egyptian Bollworm* (*Earias insulana*).—The following percentages of attack were calculated:

	1924.	1925.	1926.
January	—	1·8	2·1
February..	4·4	10·2	4·1
March	2·0	11·8	5·9
April	—	5·0	2·7

7. Dura.

Dura Aphis appeared in August and September with a rapid rate of increase. A marked decrease occurred in October, which was followed by another rise in numbers in December and January.

Stem-borer (*Sesomia cratica,* Led.) was present in December and January in the stems of Buttig. This followed an attack on stem and root earlier in the season.

Andat and *Dura Red Bug* (*Lygœum Sp.* ?) attacked the ripening grain in September.

8. Lubia.

Wilt appeared in this crop in September, and increased during October. This diminished later in the season.

CHEMICAL AND ENTOMOLOGICAL RESEARCH PROGRAMME FOR THE GEZIRA FOR THE SEASON 1927-28

I.—Chemical.

(*a*) Movement of alkali in soil under different conditions.

(*b*) Movement of irrigation water.

(*c*) Variations in nitrate content.

(*d*) The properties differentiating soils from good and bad plots.

(*e*) The effect of water penetration by flooding and by the addition of gypsum.

(*f*) Extension of the Gezira soil survey.

(*g*) The quantity of gypsum required for soil amelioration, and the best method for its application.

(*h*) The amount of organic matter in plots at the Gezira Research Farm under different treatments.

(*i*) The relation of plant development to methods of watering (joint experiment with the Government Botanist).

(*j*) Soil moisture investigations under various conditions.

(*k*) Humus investigations in farmyard manure plots.

II.—Entomological.

The chief groups of insects to be investigated will be:

(*a*) Termites.
(*b*) Thrips.
(*c*) Beneficial insects.
(*d*) Store pests.

(*a*) *Termites.*—1. The material acquired during the previous season will, as far as possible, be determined with a view to ascertaining the diagnostic characters of the species of the Gezira district and the recognition of their castes.

2. The life-histories of those species of which the identity is certain will be followed out as far as possible during a consecutive period of twelve months, special attention being paid to those species which attack cotton.

3. The distribution of these determined species will be further ascertained with the object of detecting the factors which govern their distribution in the Gezira.

4. The establishment of observation nests in the insectary, which has hitherto been unsuccessful, will again be attempted in specially constructed containers.

5. Sites of Termite attack on cotton during the preceding season in certain places will be kept under observation for the purpose of following the history of nests in those sites.

6. Experiments on the protection of buildings against Termites now being carried out in Khartoum will be duplicated in the Gezira.

(*b*) *Thrips.*—Working on the results obtained during the previous year, the investigation will proceed by methods designed to elucidate the internal physiological conditions of the plant which favour Thrips attack. Briefly the lines to be followed are:

1. Investigation of the sap of the plant under conditions suited and unsuited to Thrips, as regards—

(i.) Hydrogen-ion concentration in the leaf.
(ii.) Carbohydrate content of sap.
(iii.) Leaf texture.

2. The life-cycle of the Cotton Thrips will be followed continuously throughout a season providing natural conditions of environment, so far as the exigencies of observation will allow.

3. It is proposed to grow plants in water cultures of known chemical constitution with a view to finding differences in the susceptibility to attack.

4. Field observations.

(*c*) *Beneficial Insects.*—1. The parasitic hymenoptera, bred out during the first quarter of the year 1927, will be determined as far as possible, and, with the assistance of the literature on the subject, certain species will be chosen for further investigation. These will be the species which offer most promise as practical control agents.

2. The life-history of the Cotton Stem-borer egg-parasite will be followed both in the laboratory and the field.

3. Investigations will be commenced on the effects upon the activities of the parasites of cotton pests of the rotation and juxtaposition of crops in the Gezira.

(*d*) *Store Pests.*—The collection, breeding, and determination of the store pests of the Gezira area will be undertaken as far as other work will allow.

WORK OF THE SECTION OF PLANT PHYSIOLOGY AND PATHOLOGY

BY

R. E. MASSEY,

Government Botanist.

A. PHYSIOLOGY.

1. Date of Application of Ammonium Sulphate.

Repeated reference is made in the foregoing report by the Government Chemist to the use of ammonium sulphate, and the results obtained at Shambat for the season 1925–26 are quoted (p. 101).

The figures from the past season are now available, but as a departure from the usual practice is contemplated this year, it will be well to review the position briefly.

In Table I. (p. 121) are given the nitrate figures in parts per million obtained at Shambat from the examination of the soil of the control plots by the Government Chemist, and the month in which ammonium sulphate was applied with optimum results to the crop is indicated by brackets around these figures.

The technique and layout was the same throughout the series of experiments.

It will be observed that there are strong indications of a seasonal variation in the nitrate content of the soil, and during the coming season the experiment has been modified to the extent that ammonium sulphate will be added at both periods of low nitrate content—*i.e.*, after the rains, and again at the onset of winter. The experiment has also been extended by the introduction of urea for the first time in this country.

It is highly probable that the fall in nitrate content in August is due to the leaching effect of rains, but two other variations have still to be accounted for—*i.e.*, the fall during the fallow period preceding the rains, and the fall in winter.

What biological work the writer has been able to undertake indicates that as the soil dries out, a partial sterilization takes place,

TABLE I.—SHAMBAT: APPLICATION OF AMMONIUM SULPHATE TO COTTON.

Year.	*Nitrate Figures (Parts per Million).*												*Results Obtained from Use of Ammonium Sulphate.*
	May.	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*March.*	*April.*	
1921–22	—	—	*	—	(28)	57	177	138	154	120	136	—	Increase of 18·3 per cent. two months after sowing.
1922–23	—	—	94*	17	(41)	124	56	111	75	86	52	—	Increase of 13 per cent. two months after sowing.
1924–25	—	17*	128	(81)	99	179	266	81	81	53	118	—	Increase of 20 per cent. two months after sowing.
1925–26	73*	291	143	110	170	124	114	145	203	124	139	—	No increase (see note on page 101).
1926–27	239	118	50*	(116)	(103)	140	60·3	200	138	138	109	—	Increase of 38 per cent. one month after sowing, and 32 per cent. two months after sowing.

NOTES.—(*a*) 1926-27 results: This hosh was dressed with 10 tons of a poor quality cattle manure before sowing, but the seasonal trend is still apparent.

(*b*) Parentheses indicate month in which increase quoted was obtained.

(*c*) Asterisk denotes sowing date.

but that fungi, being very resistant to drought, become numerically greater, and these are largely responsible for the destruction of the organic residues, during which process they draw on the nitrate of the soil for energy.

A noteworthy feature of the soils examined at Shambat is the comparative smallness of the bacterial count obtained; this, however, agrees with the results obtained by Prescott in Egypt.

Although methods are not included in this report, it will be advisable to mention at once that the culture medium on which the following counts were made was one developed by the writer about 1912 as the result of the varied counts obtained on synthetic agar and a standard Lemco agar.

To three parts of a synthetic agar containing the usual nutrient salts and 0·1 per cent. dextrose, one part of standard Lemco-peptone broth was added, the reaction being rendered neutral to phenolphthalein.

For azotobacter and protozoa a mannite medium was used, and for fungi a synthetic medium rendered slightly acid by means of acid phosphate.

Latterly all media have been standardized to a definite pH.

The dilution method was used for protozoa.

The following figures are given in illustration of the results obtained at Shambat (they represent millions per gram of dried soil):

(*a*) Fallow soils prepared for wheat, November 9, 1924: 3·6; 2·4; 0·75; 0·8; 1·0; 6·0; 0·6; 2·0.

(*b*) The same later, November 21, 1924, after first irrigation: 4·7; 1·65; 2·95; 2·6; 1·4; 0·58; 1·9; 2·13.

(*c*) The same later, January 1, 1925, crop growing: 5·6; 2·6; 3·7; 3·3; 1·8; 1·3; 1·8; 1·1.

(*d*) The same later, May 10, 1925, crop harvested: 0·3; 0·75; 0·75; 0·6; 0·45; 0·45; 3; 0·52.

At the time of the first examination (*a*), mentioned above, the fungi were as follows: 0·425; 0·550; 0·675; 0·450; 0·4; 0·75; 0·67.

The figures obtained from the same series in December were: 0·97; 0·97; 0·45; 0·82; 0·67; 0·9; 1·5.

Unfortunately the examination was not continued, and there are no records corresponding to the last bacterial count.

The relation between bacterial count and nitrate in the soil is shown by the table given on p. 123, which represents the average of a large number of examinations made a few years ago at Shambat:

TABLE II.

(*a*) Cotton Plot (Ridged).

	Sept.	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*
Bacteria in millions per gramme of dried soil	0·8	2·1	2·8	1·6	1·8	1·7	1·0
NO_3 p.p.m.	28	57	177	138	154	120	138

(*b*) Wheat Plot (not Ridged).

	Nov. (before Watering).	*Nov. (after Watering).*	*Dec.*	*Jan.*	*Feb.*	*Mar.*
Bacteria in millions per gramme of dried soil	3·1	2·4	2·1	0·5	3·6	2·8
NO_3 p.p.m.	42	35	11	7	12	11

Only four Gezira soils taken at the Research Farm have so far been examined, but the figures obtained strongly resemble the above. The details are as follows:

(*a*) Fallow:

First 4 inches, 1·4 millions per gram of dried soil.
Second 4 inches, 1·2 millions per gram of dried soil.
Third 4 inches, 0·92 million per gram of dried soil.

The plates were overgrown with fungi after seventy-two hours.

(*b*) Prepared for cotton following lubia:

First 4 inches, 2·6 millions per gram of dried soil.
Second 4 inches, 1·6 millions per gram of dried soil.
Third 4 inches, 1·24 millions per gram of dried soil.

(*c*) Fallow soil, 1·35 millions.

(*d*) Soil at the end of the cotton crop, very hard and caked, 0·85 million.

The influence of the water content of the soil is shown in the following table:

TABLE III.—Shambat.

Moisture Content (per Cent.).	*Bacteria in Millions per Gramme of Dried Soil.*
16·28	4·78
12·2	2·35
10·0	1·65
8·28	0·6
5·0	0·36
4·4	0·240
2·9	0·120
2·85	0·150

The last two figures were taken from a light sandy soil; the remainder represent successive determinations from a plot in a wet and dry fallow experiment.

Azotobacter chroöcoccum, Bey., is invariably present, and generally in large numbers. Nitrosomonas and nitrobacter have not yet been isolated. It is interesting to note that fallow soils in the Sudan rise in temperature during the summer months well above what is generally recorded as the thermal death-point of these organisms in text-books.

Protozoa are always present, but have never yet been found in large numbers. They appear to increase in cultivated soils, where up to 1,000 per gram have been counted, and to decrease rapidly under fallow conditions, the lowest count obtained being 50 per gram.

Mastigophora spp. predominate in both fallow and cultivated soils, and are most numerous in the uppermost layers. Rhizopoda and ciliata are also present, the latter being least common of all three groups. This observation apparently holds true for the Gezira soils examined.

No protozoa have been found below 2 feet, whereas bacteria have been found as low as 10 feet below the surface. Azotobacter also rarely penetrate below 2 feet.

Finally, it might be mentioned that there are grounds for thinking that the sediment from the Nile flood may owe part of its fertilizing value to the fact that it contains nitrifying organisms, including many azotobacter. A count made during the same year as the above recorded observations gave 0·35 million organisms per c.c. The water then contained 110 parts of sediment per 100,000, and a nitrate content, estimated by the phenol sulphonic acid method, of 1·5 parts per million. On incineration the sediment lost 0·422 per cent.

One experiment is worth recording.

Eighteen tumblers containing each 400 grams of soil were inoculated with—

(*a*) Nile sediment from 500 c.c. of river water.
(*b*) 25 c.c. of a fresh culture of azotobacter.
(*c*) Controls, watered with distilled water.

After five weeks the nitrate content of the tumblers was—

(*a*) 364 parts per million.
(*b*) 291 parts per million.
(*c*) 14 parts per million.

Washed and sterilized sand treated as above and incubated at the same time gave on analysis—

(*a*) No nitrate.
(*b*) Traces of nitrate.
(*c*) No nitrate.

2. The Effect of Gypsum on the Cotton Crop.

In view of the inconclusive results quoted in the report of the Government Chemist (p. 102), it will be worth while to record earlier experiments with cotton at Shambat.

In 1922–23 an increase of 10 per cent. was obtained by the application of 1 ton of gypsum, and 21 per cent. with 2 tons of gypsum per feddan. The pH of the plots after an interval of nine months were: Control, 9·4: gypsum plots, 9·27.

In 1924–25 ½ ton of gypsum gave an increase of 8 per cent.; 1 ton of gypsum gave an increase of 9 per cent.; 2 tons of gypsum gave an increase of 24 per cent.

The pH was: Control, 8·96; gypsum, 1 ton, 8·57; gypsum, 2 tons, 8·50, at the end of the crop.

3. Sulphur as a Fertilizer.

An interesting point has arisen concerning the application of sulphur during the past season, when the plot referred to on p. 102 was sown with cowpeas without any further treatment.

The adjacent plot was also sown at the same time with cowpeas, but was divided into a series of small plots, half being dressed with sulphur before sowing at the rate of 1 ton per feddan, and the remainder untreated to serve as a control. The checker-board system was, of course, used, as in all experiments.

One picking only of seed was weighed, but with interesting results, there being a marked increase in yield from the plot treated last year with sulphur, but no significant increase from the plots treated this season. It would appear that with sulphur the residual effect may be greater than the immediate.

During the growth of the crop, it was remarked that the sulphur actually seemed to have a depressant effect on the cowpeas, and the accumulation of salts on the ridge of the treated plots was very noticeable.

4. Green Manures and their Effect on the Soil.

The danger of adversely affecting the succeeding crop when planted too soon after green manures are ploughed has been pointed out previously. A similar decrease in yield was experienced in 1917, when lubia (*Dolichos Lablab*, L.) stubble was ploughed in at Shambat three weeks before planting cotton. The figures obtained

from a 10-feddan plot, equally divided into twenty squares with lubia and controls, were:

	Yields per feddan
Control	938·5 rottles seed cotton.
Lubia plots	757·5 „ „ „

This depressant effect seems to disappear after a few months; the actual time is uncertain, and is probably variable according to the moisture content of the soil. Laboratory observations indicate a minimum of two months when the moisture content is relatively high. In a single experiment carried out in tumblers, 47·5 per cent. of the incorporated dry lubia was decomposed in three weeks, but the moisture content was kept constant. After decomposition the usual beneficial effect of ploughing in vegetable matter is experienced.

Unquestionably it is a biological phenomenon which is worthy of closer study. No figures are available for experimental work on this subject with cotton, but a trial made in 1921–22 with wheat is sufficiently illuminating to be recorded.

In this instance the area under consideration carried a crop of lubia weighing 6·5 tons per feddan when green, corresponding to 2·7 tons of dry matter. Half of the lubia was turned in, and half was cut and carted off before ploughing. Six months then elapsed before the ground was prepared and sown with wheat.

The following table gives the results obtained from a chemical and bacteriological examination:

TABLE IV.—SHAMBAT.

Treatment.	*Nitrates in Parts per Million.*							
	*Oct.**	*Nov.* 22.	*Dec.* 5.	*Dec.* 21.	*Jan.* 15.	*Feb.* 1.	*Feb.* 16.	*Mar.* 27.†
(*a*) Lubia ploughed in whole	5	21	63	88	27	18	16	9
(*b*) Stubble only ploughed in ..	16	30	31	42	14	11	7	9
(*c*) An untreated plot under wheat ..	42	35	—	11	7	12	11	11

The bacteriological counts corresponding to (*a*) and (*b*) were:

TABLE IVA.—SHAMBAT.

Treatment.	*Millions per Gramme of Dried Soil.*						
	Oct.‡	*Dec.* 5.	*Dec.* 21.	*Jan.* 15.	*Feb.* 1.	*Feb.* 16.	*Mar.* 27.†
(*a*) Lubia ploughed in whole	6	9·0	2·8	0·7	1·9	5·5	1·3
(*b*) Stubble only ploughed in	3	2·4	3·0	0·5	0·7	2·2	1·3

* Before crop ploughed in and before sowing with wheat.
† Wheat removed. ‡ Before crop ploughed in.

Unfortunately no figures exist for the untreated plot, and no special counts for fungi were made at this time, but other work has shown that fungi become very numerous when organic matter is incorporated with the soil, and the initial relatively low nitrate content of the lubia plots in October is probably due to this fact.

5. The Effect of Manures on the Cotton Plant and on the Lint Produced.

No report on manures in connection with the cotton crop would be complete without some mention of their influence on the plant itself. Briefly it may be stated that so far no response of agricultural significance has been obtained to any except nitrogenous manures. Both potash and superphosphate have been tried without marked effect. Possibly superphosphate may hasten maturity, but the yields obtained by its use have not warranted extended trials. Nitrogenous manures, on the other hand, are always beneficial, and unless used in excess (see Fig. 1, p. 137), promote that extra vegetative growth which ultimately leads to increased fruitfulness. Too heavy doses are apt to delay the ripening of the crop, but no alteration of the maturation period of the boll itself has been noticed.

With regard to the crop, a series of tables is given below from which it will be seen that the principal effect of nitrogenous manures is to alter the ginning percentage, mainly by increasing the weight of the seed; at times it seems as if added nitrogen may also slightly affect the length of the lint. These results agree closely with those obtained by Mosseri in Egypt.

6. Water Duty and the Cotton Crop.

In the programme of research work for the Botanical Section at the Gezira Research Farm for 1927–28 (p. 61), experiments are forecasted by which the relation of plant development to methods of watering may be studied. As we possess few data from the Gezira, it will not be out of place to include a few typical results obtained at Shambat in the past. The curves are self-explanatory and should suffice for a report of this nature, but briefly it may be said that excessive watering was found to lead to heavy shedding, particularly at the apex of the curve (see Fig. 2, p. 138), and that too little water definitely stunted the growth of the plant (see Fig. 3, p. 139).

Generally speaking, an interval of fifteen days was found to be the optimum between waterings, and at this rate little difference was obtained in yield from an application of either 500 or 400 cubic metres on Shambat soils.

TABLE V.—SHAMBAT: EFFECT OF MANURES ON THE LINT.

Details of Manures.	*Sakel Cotton.*						*Weight of 100 Seeds (Grms.).*
	Length of Staple in Millimetres.			*Ginning Percentage.*			
	Year 1914–15.	*Year* 1915–16.	*Year* 1916–17.	*Year* 1914–15.	*Year* 1915–16.	*Year* 1916-17.	*Year* 1914–15.
1. 10 tons stable manure, 200 lbs. nitrate of soda, 300 lbs. superphosphate	32·8	34·8	—	32·25	30·9	—	12·0
2. 10 tons stable manure only	31·0	33·0	34·7 ± 0·04	33·1	31·6	32·6	11·0
3. 50 lbs. nitrate of soda	32·2	33·9	—	33·3	31·9	—	10·9
4. 100 lbs. ,, ,, ...	32·4	33·2	—	32·9	31·4	—	11·2
5. 200 lbs. ,, ,, ...	31·0	33·5	—	32·8	31·4	—	11·8
6. 300 lbs. ,, ,, ...	—	33·2	—	—	31·8	—	—
7. 300 lbs. superphosphate, 200 lbs. nitrate of soda ..	31·0	32·2	—	32·5	31·3	—	11·0
8. 150 lbs. ,, 100 lbs. ,, ,, ..	33·0	33·7	—	33·5	33·9	—	11·0
9. 300 lbs. ,, ...	35·0	33·8	—	34·0	32·1	—	10·6
10. 150 lbs. ,, ...	33·8	33·2	—	33·8	31·5	—	10·7
11. Lubia crop ploughed in (2)	—	33·2	33·4 ± 0·07	—	31·7	32·6	—
12. Control plots (1)	33·2	33·2	35·0 ± 0·05	33·2	32·0	32·5	10·8

NOTES.—(1) Average of 140 determinations.
(2) ,, 57 ,,
Remainder average obtained from 20 determinations taken throughout season.

TABLE VI.—SHAMBAT: EFFECT OF MANURES.

(EXAMINATION OF SEED COTTON (SAKEL), HOSHES 4 AND 6, 1922.)

A.—Sulphate of Ammonia only.

	Aug.	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Control.*
1 cwt. per feddan:								
Weight of 100 seeds in grammes	11·7	11·7	11·6	11·8	11·8	12·0	12·0	11·2
Weight of lint from 100 seeds in grammes	5·6	5·6	5·5	5·6	5·6	5·6	5·6	5·4
Ginning percentage	31·0	32·1	32·2	32·4	32·0	31·3	31·6	31·2
Length in millimetres	36·0	36·5	36·5	35·5	35·5	36·5	36·0	37·5
2 cwts. per feddan:								
Weight of 100 seeds in grammes	11·9	11·4	11·7	12·3	11·8	11·9	11·9	11·2
Weight of lint from 100 seeds in grammes	5·6	5·4	5·5	5·8	5·6	5·6	5·6	5·4
Ginning percentage	31·4	31·6	30·5	31·3	30·7	30·2	30·1	31·2
Length in millimetres	37·0	37·0	37·0	37·0	37·0	37·0	37·0	37·5

B.—2 cwts. Sulphate of Ammonia, 2 cwts. Superphosphate, 2 cwts. Potash.

Weight of 100 seeds in grammes ..	12·2	12·0	12·0	12·05	11·3	11·3	11·2	11·36
Weight of lint from 100 seeds in grammes	6·0	5·8	5·8	5·8	5·6	5·4	5·0	5·4
Ginning percentage	32·8	32·5	32·6	32·6	31·8	30·2	30·2	32·0
Length in millimetres	37·7	37·0	37·0	37·4	37·0	37·4	37·0	37·5

TABLE VII.—SHAMBAT: EFFECT OF MANURES.

(EXAMINATION OF SEED COTTON (SAKEL), HOSH 12, 1923.)

Details of Manures : Quantities per Feddan.	*Weight of 100 Seeds in Grms.*	*Weight of Lint from 100 Seeds in Grms.*	*Ginning Percentage.*	*Length of Staple in Mm.*	*Yield in Lbs.*
2 cwts. sulphate of ammonia 2 cwts. sulphate of potash.. 2 cwts. superphosphate ..	12·4	6·0	33·8	37·8	840
1 cwt. sulphate of ammonia 1 cwt. sulphate of potash .. 1 cwt. superphosphate ..	12·0	5·8	33·0	37·8	816
2 cwts. sulphate of potash.. 2 cwts. superphosphate ..	11·4	5·7	32·3	37·8	780
1 cwt. sulphate of potash .. 1 cwt. superphosphate ..	11·4	5·6	32·4	37·6	768
2 cwts. sulphate of potash..	11·7	5·6	32·6	37·7	797
1 cwt. sulphate of potash ..	11·7	5·6	32·4	37·7	800
2 cwts. superphosphate ..	11·5	5·5	32·8	37·4	709
1 cwt. superphosphate ..	11·4	5·7	32·8	37·5	729
Control	11·6	5·6	32·5	37·6	753

NOTES.—(1) Heavy crop of lubia afin taken off and stubble ploughed in about one month prior to planting with cotton.

(2) Average probable error of length determinations ±0·06

Regarding the lint, little or no difference was found when water was applied within reasonable limits* (see Tables VIII. and IX.).

The object of the experiment outlined in the programme for the coming season is to ascertain whether little and often is not better than the usual spacing of fifteen days between waterings at the critical period when the flowers are forming and the bolls developing.

The writer's particular part in the experiment lies in endeavouring to procure some figure for the amount of water transpired by the plant during this period of growth, and mention is made here simply because recent work has indicated that the loss mentioned above (p. 97) from transpiring plants is probably an outside figure, for in a light breeze the estimated loss is approximately 12 tons a day for a field containing 23,500 plants of a development commonly found in the Central Gezira region. The figures obtained for loss by transpiration vary very greatly with alterations of temperature and wind force, so that any estimate can only be a rough approximation.

TABLE VIII.—Shambat: Duty of Water—Time Influence on the Lint—400 Cubic Metres Applied.

Year.	*Intervals of Ten Days (Length in Mm.).*			*Intervals of Fifteen Days (Length in Mm.).*			*Intervals of Twenty Days (Length in Mm.).*		
	Seasonal Range.			*Seasonal Range.*			*Seasonal Range.*		
	Max.	*Min.*	*Av'ge.*	*Max.*	*Min.*	*Av'ge.*	*Max.*	*Min.*	*Av'ge.*
1915 ..	36·3	33·1	35·0	36·8	34·3	35·0	35·7	33·0	34·0
1916 ..	37·0	30·0	33·2	37·0	30·0	33·2	37·0	30·0	33·0
1917	500 cubic metres		35·8	—	—	36·5	—	—	34·5
	400 „ „		36·5	—	—	35·7	—	—	35·0
	300 „ „		36·4	—	—	34·8	—	—	35·0

Average P.E. of above ±0·05.

Year.	*Intervals of Ten Days (Breaking Strain in Grms.).*			*Intervals of Fifteen Days (Breaking Strain in Grms.).*			*Intervals of Twenty Days (Breaking Strain in Grms.).*		
	Seasonal Range.			*Seasonal Range.*			*Seasonal Range.*		
	Max.	*Min.*	*Av'ge.*	*Max.*	*Min.*	*Av'ge.*	*Max.*	*Min.*	*Av'ge.*
1915 ..	5·5	4·7	5·2	5·5	5·4	5·5	5·7	5·0	5·3
1916 ..	6·8	3·2	5·03	6·8	3·2	5·13	6·7	4·0	4·9
1917 ..	6·6	6·7	5·1	6·0	4·4	5·28	6·1	4·9	5·3

* See, however, Fig. 4.

TABLE—IX. Shambat: Date of Watering Experiment—Effect of Varying Quantities on Lint—Interval Fifteen Days (Sakel Cotton).

Year.	Length in Millimetres.			Number of Determinations.	Breaking Strain in Grammes.			Ginning Percentage.			Watering (Cubic Metres).
	Maximum.	Minimum.	Average.		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	
1915	37·2	32·0	35·3	27 from 3–12–14 to 17–4–15	5·9	4·7	5·3	—	—	—	500
	39·0	32·0	35·3	Ditto	5·6	5·3	5·4	—	—	—	400
	35·2	32·0	35·3	Ditto	5·8	5·0	5·4	—	—	—	300
1916	36·3	31·0	32·9	54 from 22–1–16 to 22–4–16	6·2	3·7	4·9	35·4	27·4	31·6	500
	36·6	31·0	33·3	Ditto	6·0	3·9	5·1	35·0	26·3	31·5	400
	35·5	31·5	33·2	Ditto	6·1	3·4	5·1	35·1	27·6	31·6	300
1917	37·0	33·3	35·6	33 from 21–12–16 to 3–3–17	6·0	5·1	5·3	32·8	30·0	32·0	500
	37·6	34·6	35·7	Ditto	5·5	5·1	5·3	32·5	30·0	31·8	400
	36·6	33·0	35·3	Ditto	5·8	4·7	5·3	32·8	28·6	31·3	300

Note.—*Each* determination of Length =average of 7 trials. Average P.E. of figures given ±0·04.
" " Strength= " 50 "
" " G.P. = " 250 grammes.

Past results on the determination of the moisture content of the soil at wilting-point are interesting, wilting of seedlings commencing in heavy Shambat soils at 11·4 to 15·3 per cent. of moisture, according to the position of the plants, while death occurred at from 8 to 10 per cent.

Recent experiments still in progress, but with Gezira soil, differ little from the above, wilting occurring in young cotton plants 2 feet high when the soil moisture content was reduced to 17 per cent.

7. Variations of Climate and the Cotton Crop.

The influence of the climate on the cotton plant is dealt with in detail by Mr. Lambert elsewhere in this report (p. 34 *et seq.*); it only remains for the writer to add a little supplementary evidence of a different character showing the large amount of leaf-fall which may result from severe water-strain caused by high evaporation associated with much wind, and combined with comparatively low temperatures.

The plot in question was the " Observation Plot," and was planted on July 22, 1926, a date which leads to early senescence of the lower leaves.

The weight of the aerial portion and the leaf area throughout the season are shown in Fig. 5 (p. 141), together with the graphs of minimum temperatures and evaporation as recorded by the Piché instrument.

Some allowance must be made for the time interval between the variation in climate and the actual fall of the leaf, but as the time necessary for the formation of abscission layers is at present unknown, this is omitted.

Coincident with the fall in temperature is the lessening of the light values as obtained by means of an acetone methylene blue gauge (see Table X.), which records the intensity of the ultra-violet radiations in the incident light. The precise effect of such seasonal variations is unknown, but it is a certain fact that the sum-total of the environmental factors from November onwards throughout the winter months is a slackening of growth processes generally in such tropical crops as cotton.

TABLE X.—Shambat: Ultra-Violet Light (Daily Average for the Month).

1926.						1927.
July.	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*
8·8	12·9	11·0	9·6	4·8	2·3	3·6

Finally, attention was drawn a few years ago to the fluctuations in lint characters which occur throughout the season, when samples of cotton sent to the Fine Cotton Spinners' Association failed to support in spinning trials the favourable verdict passed by expert graders on the bulk.

The figures given in Table XI. were obtained by Dr. W. L. Balls when attempting to explain this anomaly, and are included as they show the order of the differences which may exist between points on such a graph as that shown in Fig. 4; they also illustrate the necessity for furnishing a truly representative sample for spinning tests.

The explanation of the divergence of opinion between the graders and the spinners lay in the fact that the spinners received a sample taken when the lint curve had reached one of those low points which occur normally and which appear to be correlated with adverse environmental conditions during the ripening of the boll.

TABLE XI.

	Strain No. 77.	*Strain No.* 95.	*Strain No.* 111.
(*a*) Hair weight (*i.e.*, average of 1 cm. cut from the middle of the hair):			
Good sample	0·00145 mg.	0·00130 mg.	0·00151 mg.
Poor „	0·00168 „	0·00163 „	0·00193 „
(*b*) Ribbon width (average of 100 hairs):			
Good sample	0·0180 mm.	0·0186 mm.	0·0190 mm.
Poor „	0·0185 „	0·0182 „	0·0183 „
(*c*) Coefficient of Variation of (*b*):			
Good sample	16·6 per cent.	22·7 per cent.	18·8 per cent.
Poor „	18·3 „	19·8 „	15·9 „
(*d*) Hair length, computed from "Sorter" curves:			
Good sample	1·02 ins.	1·28 ins.	1·22 ins.
Poor „	1·05 „	1·11 „	1·10 „

B. PATHOLOGY.

8. Bacterial Disease of Cotton.

Thanks to the recent distribution of work, by which Mr. M. A. Bailey has taken charge of plant-breeding investigations, it was possible for the writer to devote more attention to the disease commonly known as "Blackarm," caused by *Pseudomonas malvacearum*, E. F. Smith. The results of the past season's work have been

printed in the *Annals of Botany*, vol. xli., no. clxiii., July, 1927, but may be briefly summarized here.

(*a*) Evidence has been obtained to show that the development of the bacterial disease of cotton caused by *P. malvacearum* in the seedling stage is confined to a definite range of soil temperatures.

(*b*) At soil temperatures of 11° to 15° C. infection is slow, and in the case of lightly infected seed may be missed.

(*c*) From 16° to 20° C. infection is generally obtained, but again it is not usually serious if other environmental conditions are favourable for the growth of the seedling.

(*d*) From 21° to 26° C. infection is severe.

(*e*) Above 26° to 28° C. the infection again fades in intensity.

(*f*) Above 28° C. little or no infection is obtained.

(*g*) At 30° C. the plant is generally immune. Experimental evidence suggests that the regional distribution of the disease may be explained on these grounds.

(*h*) Some account was given of the internal changes associated with varying temperatures, and indirect support is afforded to Faulwetter's work on the spread of the disease by rain.

Since the above account was written, a considerable amount of information has been obtained both from the field and from laboratory work. In particular the relation between rainfall at sowing and the development of the disease has been studied in the Gezira, at Shambat, at Kassala, and at Tokar (see Illustrations A and B), and in each instance the evidence derived from the field strongly supports the laboratory work described in the above-mentioned note.

Additional evidence from last year's crop is given by Mr. Craig in Section E, General, of his report (p. 80), whilst the diagram given illustrating the effect of rainfall on a carefully planned "Times of Planting" experiment at Shambat this season further supports the view that the occurrence of the disease is directly related to the temperature at sowing, and that this temperature is definitely connected with rainfall (see Fig. 6).

The same "Times of Planting" experiment is affording valuable material for microscopical examination, and already it has been possible to trace the parasite in the ovary before fertilization. The extent of the systemic infection may be judged by the fact that wilting plants have recently been submitted to Mr. Lambert in which the root was visibly attacked, an important point which needs careful investigation.

An interesting side-line of investigation, the results of which have not yet been published, is the possibility of freeing seed from

the parasite by heat. It was found that if cottonseed is slowly and carefully dried at 60° C. it may subsequently be heated at 100° C. for several hours without serious damage, and that the amount of infection in the sample is thereby greatly reduced. This method offers possibilities for the production of disinfected seed for control purposes, and also for propagation, and will be particularly valuable where pure lines are concerned.

Finally, interesting records of the soil temperatures during the growth of the cotton crop in Egypt have just arrived in which it is seen that the average temperature at sowing is about 17° C. for at least a fortnight after sowing in those depths in which the seed normally germinates.

Now what evidence we have points to the first few days of germination as being the critical time in which the fate of the parasite is determined, so that we have here a definite clue to the comparative immunity of Egypt from this pest. That it does exist, however, is certain from the fact that Egyptian seed always produces a certain number of diseased plants when grown under the proper conditions, and the writer himself has seen traces of the disease in Egypt on cotton plants.

The very important phenomenon of the power of the parasite to lie latent within the host is hereby raised, but cannot be discussed in this report. It has been strikingly demonstrated in the Gezira with Tokar seed this year.

9. Root Rot of Cotton.

A disease often resulting in the death of the cotton plant, and commonly known as "wilt" in this country, is widespread in the Gezira, but fortunately the losses are not generally serious.

The fungus *Rhizoctonia Solani*, Kühn, has been isolated and identified, and artificial inoculations made in the laboratory reproducing characteristic symptoms, so that its pathogenicity seems proved. The fungus attacks in the Gezira both Egyptian and American cotton, and is also found on lubia (*Dolichos Lablab*, L.). Elsewhere it attacks a great variety of hosts, the latest victim at Shambat being Groundnuts (*Arachis hypogea*, L.).

Time has only permitted of a preliminary investigation, and for reasons of convenience lubia was chosen as the host.

On this plant a definite temperature relationship was established, heavy infection occurring at 18° and 20° C., with diminished infection at 22° C. and immunity over 27° C., even when the soil was kept continuously moist. In actual practice it has been found that a warm,

dry soil acts as an effective check, and that if this is obtainable, resowings may safely be made in infected soil.

It would appear that the disease is generally distributed throughout the Sudan.

10. Leaf Curl of Cotton.

A curious disease in which the tissues of the leaf are thickened and curled occurs in the Gezira and elsewhere, and is mentioned here for the sake of record. The symptoms appear to be similar to those reported in Nigeria, but nothing is known of the causal factor. Careful watch is being kept, and inoculation experiments are in progress.

C. PROGRAMME FOR 1927–28.

Inasmuch as this Report is mainly concerned with the Gezira, only such items are now included as have a definite connection with that region.

(*a*) *Physiology.*—(1) "Times of Planting" experiment with particular reference to the bud-shedding, development of nodes, and occurrence of disease.

(2) Observation Plot from which developmental curves, dry weight, and leaf area are obtained.

(3) A comparison of urea and ammonium sulphate as a source of nitrogen. Leaf area and dry weight records taken.

(4) Estimation of losses of water by transpiration.

(*b*) *Pathology.*—(1) Bacterial disease of cotton in all possible aspects—*i.e.*, temperature relationship, transmission by seed, infection by soil and water, secondary infection, disinfection of seed, secondary hosts, etc.

(2) Rhizoctonia Wilt, conditions requisite for infection.

(3) Cause of Leaf Curl.

(*c*) *Plant Introduction.*—Green manures, fodder crop, and trees.

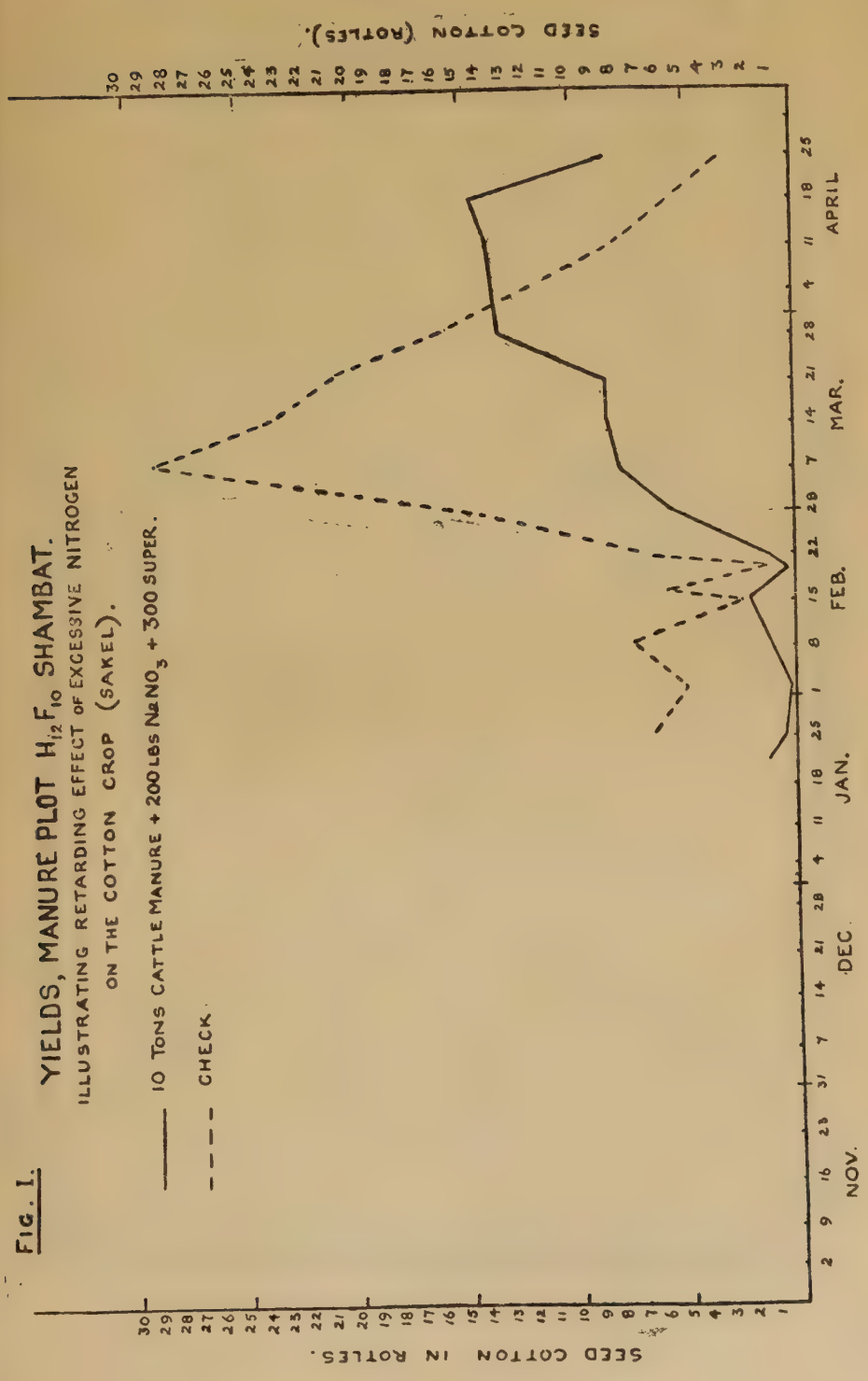


Fig. I.
YIELDS, MANURE PLOT $H_{12}F_{10}$ SHAMBAT.
ILLUSTRATING RETARDING EFFECT OF EXCESSIVE NITROGEN ON THE COTTON CROP (SAKEL).
10 TONS CATTLE MANURE + 200 LBS $NaNO_3$ + 300 SUPER.
CHECK
SEED COTTON IN ROTLES.
SEED COTTON (ROTLES).
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL

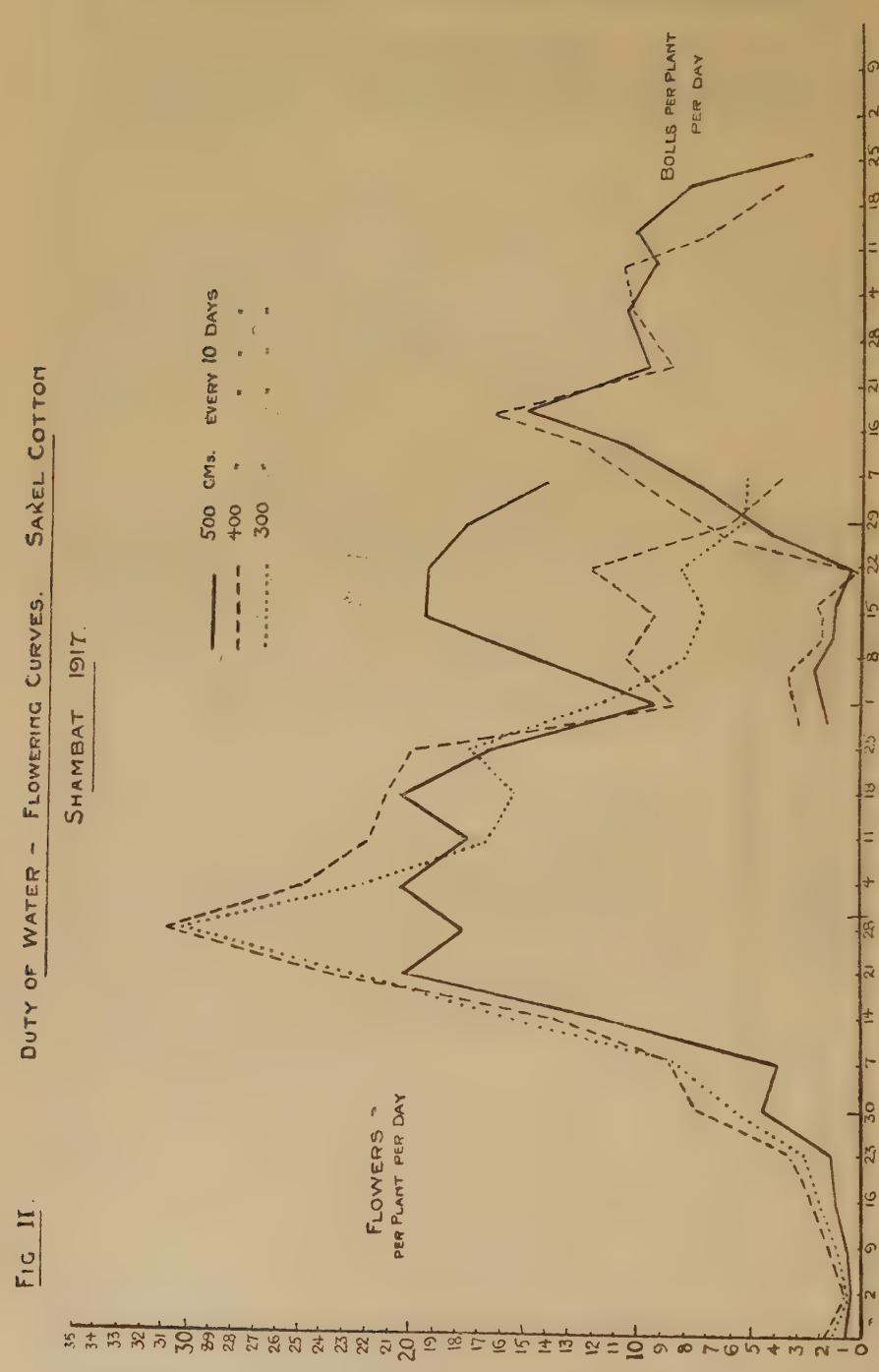
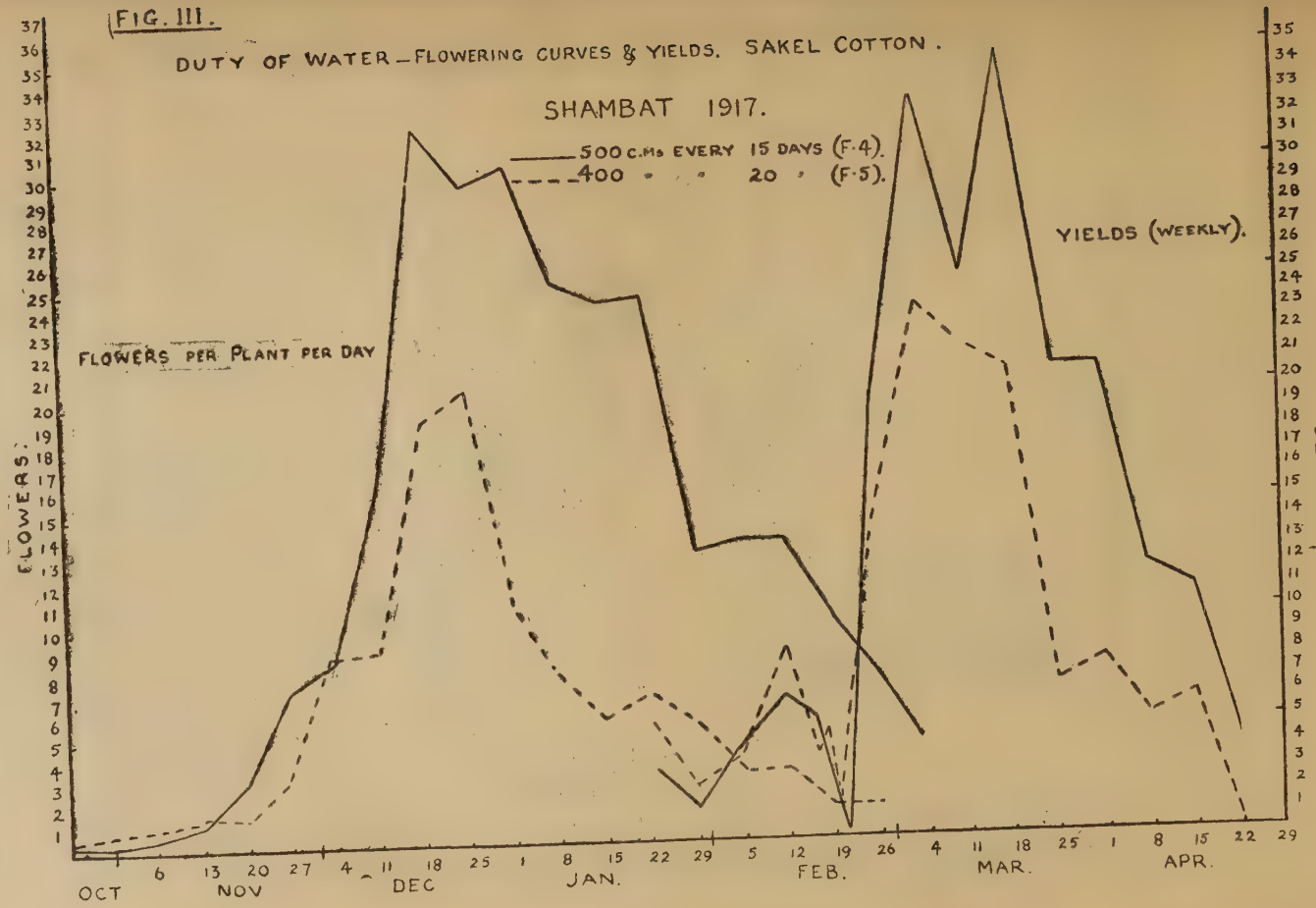


Fig II.
Duty of Water - Flowering Curves. Sakel Cotton
Shambat 1917.
500 Cms. every 10 days
400 " " "
300 " " "
Flowers - per Plant per day
Bolls per Plant per day
Nov
Dec
Jan.
Feb
Mar
April
May

FIG. III.


DUTY OF WATER—FLOWERING CURVES & YIELDS. SAKEL COTTON.
SHAMBAT 1917.
500 c.Ms EVERY 15 DAYS (F.4).
400 " " 20 " (F.5).
FLOWERS PER PLANT PER DAY
YIELDS (WEEKLY).
FLOWERS.
ROTLES.
OCT
NOV
DEC
JAN.
FEB.
MAR.
APR.

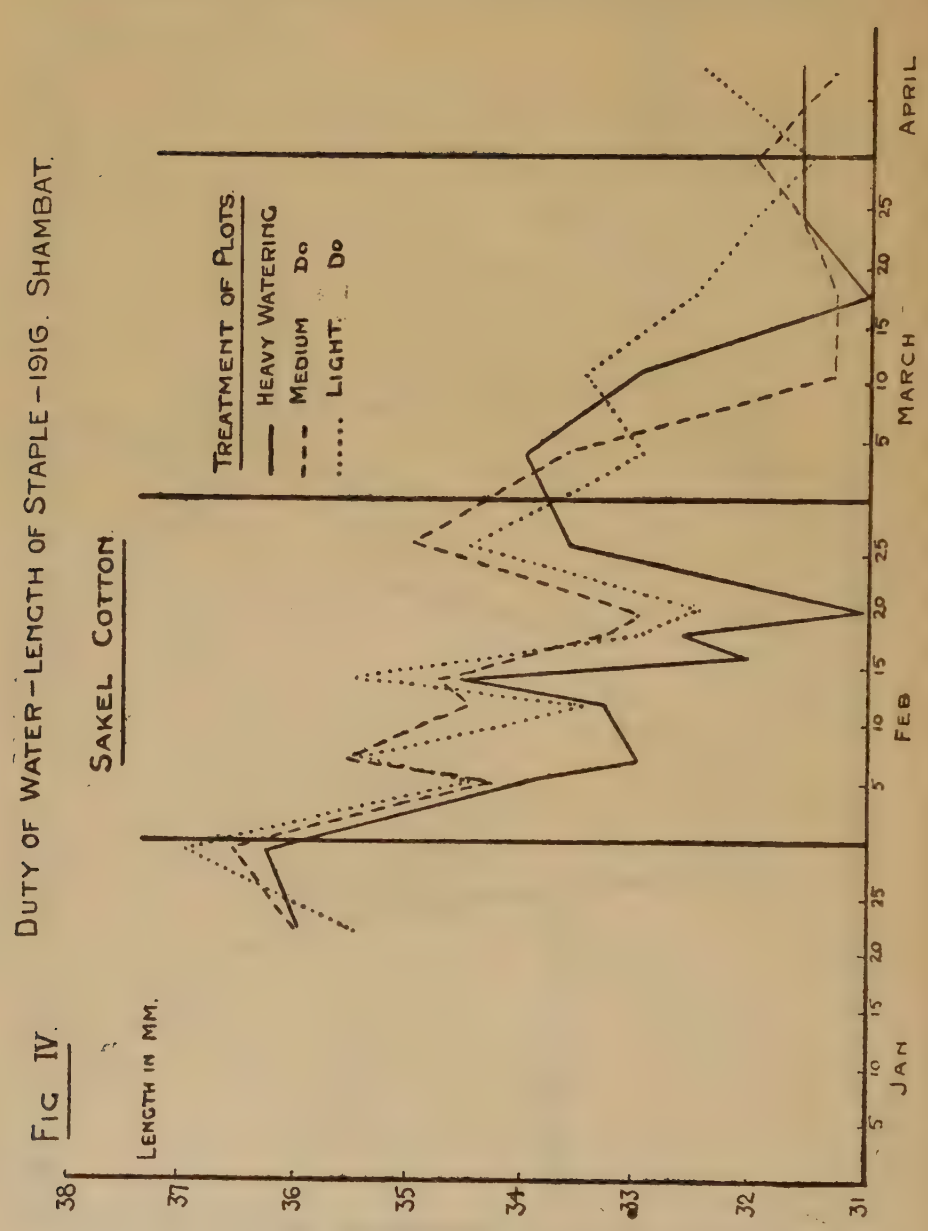


FIG IV.
DUTY OF WATER - LENGTH OF STAPLE - 1916. SHAMBAT.
SAKEL COTTON.
LENGTH IN MM.
TREATMENT OF PLOTS.
HEAVY WATERING
MEDIUM Do
LIGHT Do
38
37
36
35
34
33
32
31
JAN
FEB
MARCH
APRIL
5
10
15
20
25

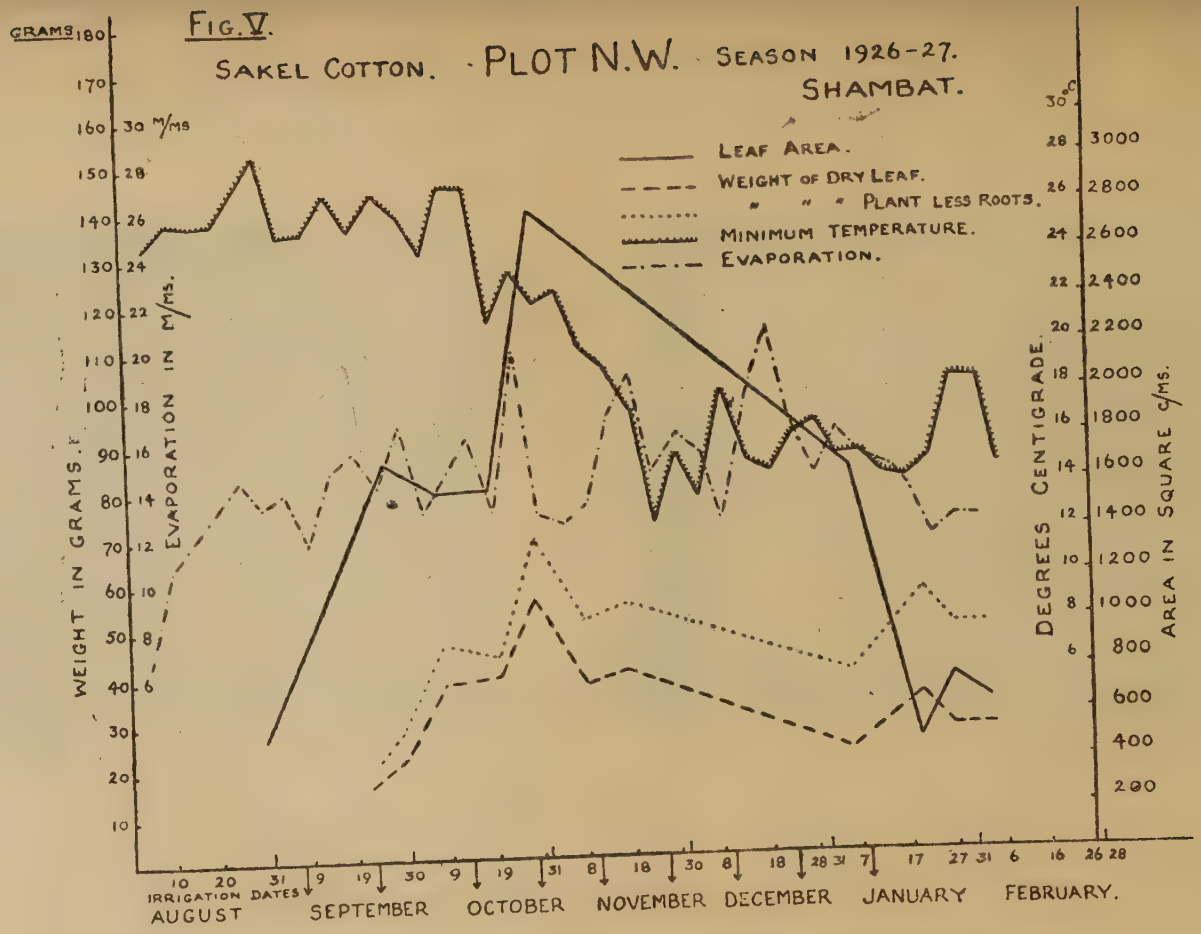
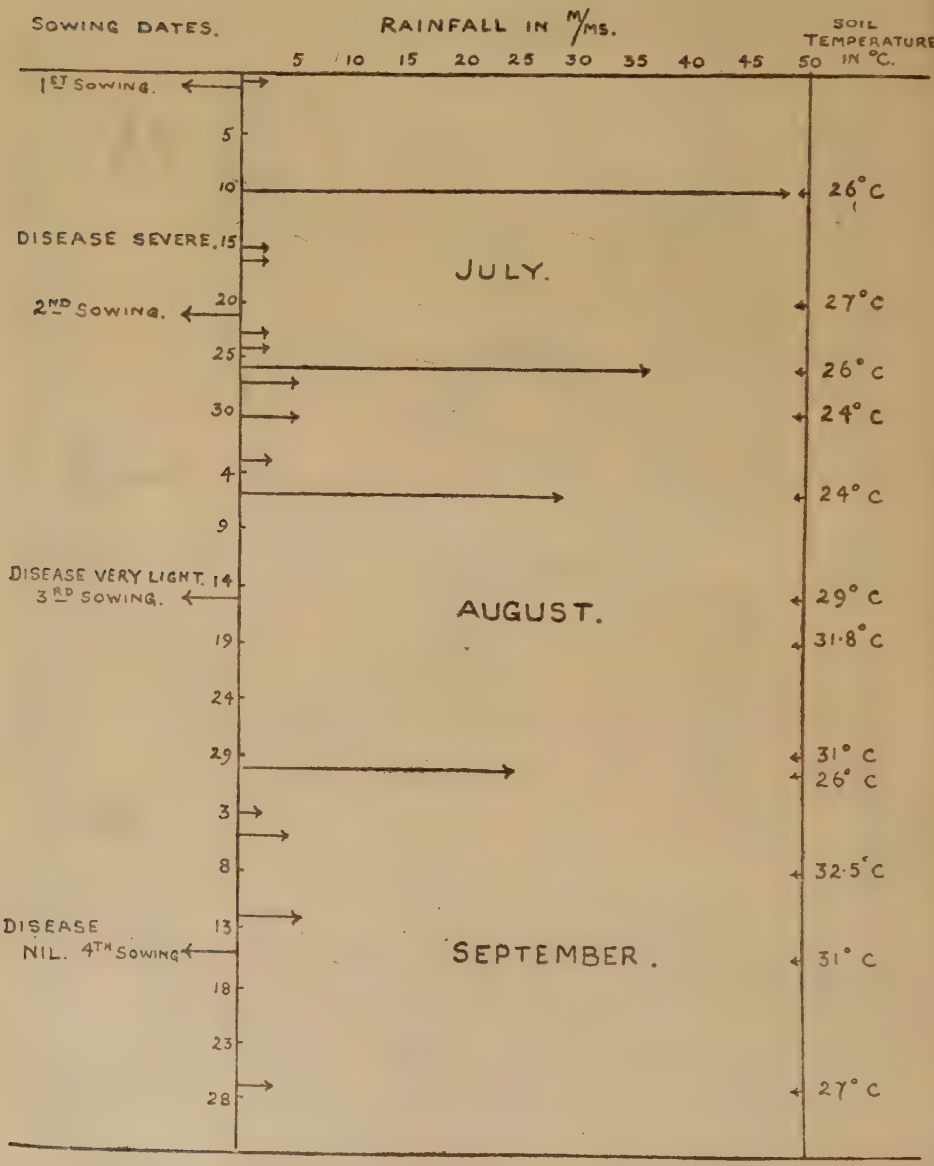


FIG. V.
SAKEL COTTON. PLOT N.W. SEASON 1926-27.
SHAMBAT.
LEAF AREA.
WEIGHT OF DRY LEAF.
" " " PLANT LESS ROOTS.
MINIMUM TEMPERATURE.
EVAPORATION.
GRAMS
WEIGHT IN GRAMS.
EVAPORATION IN M/MS.
DEGREES CENTIGRADE.
AREA IN SQUARE C/MS.
IRRIGATION DATES
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY.

FIG. VI.

RAINFALL, SOIL TEMPERATURE (5 cms) & BACTERIAL DISEASE.

SHAMBAT, 1927.



BLACKARM CONTROL EXPERIMENT: FIGS. A AND B SHOW ADJACENT PLANTS—PLOTS REPEATED SIX TIMES.

FIG. A.—INFECTED SEED SOWN WITH RAIN.

FIG. B.—INFECTED SEED SOWN IN DRY INTERVAL.

WORK OF THE PLANT-BREEDING SECTION—SEASON 1926-27*

BY

M. A. BAILEY,

The Empire Cotton Growing Corporation's Plant Beeeder.

PART I.—INTRODUCTORY.

Work on cotton has been carried out on the lines indicated in last year's report.

The behaviour of the crop at Shambat was exceptional, and the pickings were so poor in quantity and came in so slowly that the season had to be prolonged right into May, 1927, a circumstance which delayed very considerably the working-up of results, and rendered the preparations for the coming season difficult to carry out in sufficient time.

This feature was not peculiar to Shambat alone, but was shared by all the Government Pumping Stations situated along the Nile at varying distances up to 200 miles north of Khartoum.

The general drop in yield, compared to the previous season, is so striking that the following figures are reproduced in order to illustrate it:

YIELDS AT PUMPING STATIONS IN 1925–26 AND 1926–27 COMPARED. (YIELDS GIVEN IN LARGE KANTARS† PER FEDDAN.)

	1925–26.	1926–27.
Shambat	2·7	1·1
Gendettu	5·2	2·6
Kitiab	4·5	3·3
Mikeilab	4·7	3·3
Bouga	3·7	2·1
Nuri	5·1	3·8
Gureir	3·3	3·2
Ghaba	3·9	1·5

This general depression in yield was not shared by the Gezira tract, including the Government Pumping Station at Kamlin, where excellent yields were obtained in all cases. Kamlin is situated at the northern end of the Gezira area, and is relatively close to Shambat.

* May 1, 1926–April 30, 1927.

† A large kantar=315 lbs. of seed cotton.

The results at the Experimental Farm at Shambat have naturally been very disappointing, and the yield of seed from individual plants in the breeding plots has been extremely low in many cases.

The full reason is difficult to arrive at, but it may be taken as certain that exceptionally heavy depredations by the Sudan Bollworm during the early flowering season have been responsible for a considerable part of the loss in some cases at any rate. This would certainly seem to have been the case at Shambat, and reports of severe attacks were also received by the Government Entomologist from some, but not all, of the Pumping Stations concerned.

The possible effects of climate are dealt with a little further on.

Staff.

The permanent staff of the section has been increased by the provision of a post for an Assistant Plant Breeder. This has been filled by Mr. H. E. King, who was appointed on June 18, 1926. This additional appointment has enabled the very large programme of work which was laid down for the season to be carried out satisfactorily.

In other respects the staff remains as it was last year, except for certain changes in the Sudanese personnel occupying the posts.

During the course of the season the Empire Cotton Growing Corporation decided to attach Mr. F. E. Kenchington, who had just completed a studentship course at Trinidad, to this section for a year's further training. Mr. Kenchington reported for duty on October 2, 1926, and his presence here has enabled the work to be extended in the direction of investigating the actual local conditions under which the plant grows. The work carried out by him is included in the body of the present report.

Buildings and Equipment.

The main laboratory and office have been satisfactorily completed, and have been in full use during the season.

The new gin-room and baling-room were completed early, but some delay was experienced in obtaining the necessary equipment.

The baling machine is a small handpress supplied by Messrs. John Shaw and Sons, of Salford, and capable of turning out small bales of from 2 to 10 lbs. weight. After some slight modifications it has produced quite satisfactory results. Baling work started on March 8, but at that time the new season's crop had not yet been ginned out, and only samples from the previous year were dealt with.

The full-sized roller-gin (Single-Action Macarthy Gin, supplied

by Messrs. Dobson and Barlow) was installed during March, but owing to delay in the provision of electrical power, ginning could not be started until well after the termination of the period at present under review (actually on June 15).

The delay in this last case was due to a change of policy as to the source of the power supply, but the final decision to connect up Shambat with the main power supply of Khartoum is in every way satisfactory from the point of view of the station, and more than compensates for the delay in getting the gin working this year.

Approval has been given for the erection of a cotton store, consisting of two iron sheds with a concrete seed-sunning floor at the back, and for the building of a suitable range of buildings close to the present laboratory for the accommodation of the Sudanese staff, together with store rooms, etc.

Neither of these buildings has as yet been commenced, and there has been considerable congestion in consequence, during the past winter, both as regards working-room for the staff and as regards storage space for cotton. There is little doubt, however, that both will be finished during the coming season, and when this has been done the development of the section in this direction may be regarded as being very satisfactorily completed.

The Experimental Farm.

No change has occurred in the area of the farm itself during the present season. Arrangements were, however, made for the renting of two pieces of land in the neighbourhood for the siting of cotton variety test plots. Both of the plots are within three miles of the farm itself, and are worked with the labour and implements belonging to the farm. One of the plots, 5 feddans in extent, is rented from native owners, the water being supplied free by the Government. The other plot of 3 feddans is situated at Kober, and is rented from Mr. Aziz Kfouri, who generously supplies the water free of cost.

Excluding these two plots, which were both entirely under cotton, the cropping of the farm in the present season has been as follows:

Cotton	23	feddans	
Dura	2¼	„	(summer 1926 only)
Berseem	12	„	
Cowpeas, etc.	1	feddan	
Wheat	2	feddans	(winter only)
Fallow and Trees	49	„	

Soil and Climate at Shambat.

Soil.—Certain observations on the nature of the soil of the Experimental Farm have been made during the season in the course of

investigations on the growth-habit of the root systems of cotton-plants. These observations are confined to four different sites on the farm only, but they tend to confirm the *general* tendency, noted in last year's report, for the surface soil to become progressively heavier as one passes from the top layer down to a certain point, where a more or less abrupt change takes place to an entirely different soil of a much lighter and often decidedly sandy character.

In the present series of observations the surface soil was noted to be heavy and brownish-grey in colour. The texture of the first 10 cms. was satisfactory. Below that the soil became progressively heavier and browner in colour, but appeared to provide a suitable medium for root development until a depth of about 40 cms. had been attained. Here the soil normally assumed a character distinctly unfavourable to root growth. It usually had a bluish tinge, and would be classed as a hard, heavy clay breaking with a short, hard fracture. This layer extended for a variable thickness, roughly between the limits of 30 to 80 cms., after which a more or less sharp transition took place to yellowish-brown, open-textured, sandy loam eminently suitable for root development.

Indications were obtained that between successive irrigations the moisture content of the soil fluctuates widely in the upper layers. This fluctuation appears to become less and less till a point is reached round about 45 cms. below soil level, where the moisture content remains relatively steady at about 18 per cent. It will be noted that this point lies within the " impermeable " layer. As one passes further down through this, the moisture content increases very slowly but steadily until the sandy layer is reached, when the percentage of water rises rapidly.

Climate.—As regards the meteorological conditions which have been experienced during the season under review, rainfall was below normal, and amounted to 70·6 mm. in all (the normal being about 125 mm.). Most of this rain fell on one day, July 31, when over 50 mm. were recorded. The more important plots had been sown about three weeks previous to this, and the young plants were sufficiently well-established and did not appear to suffer.

Observations on temperature and humidity have been kept at Shambat for the past thirteen years, and the data forwarded to the Physical Section of the Ministry of Public Works at Cairo, who have now very kindly supplied us with curves showing the daily normals representing the whole of that period. With the help of these curves it is possible to make the following analysis of the climate during the present cotton season:

	Maximum Temperature.	*Minimum Temperature.*	*Relative Humidity.*
1926. July ..	Almost consistently above normal to extent of 3° C. on the average	Generally slightly above normal.	Round about normal.
August ..	(43·5° C. recorded on August 22)		
September	About normal	About normal	Below normal (about 10 per cent. down) throughout.
October ..	About 2° C. above normal throughout	Mostly slightly below normal.	Generally much below normal (about 20 per cent. down).
November	First week above normal. Rest below normal, especially from 15th to 20th, when maximum averaged about 5° C. below normal	Normal for first week. Decidedly subnormal from 19th to 23rd (10° C. recorded on 19th); another cold spell occurred from 26th onwards, lowest temperature being 11·5° C.	Generally much below normal (about 20 per cent. down).
December	About normal	About normal except for a rather low temperature on Dec. 1	About normal.
1927. January ..	First ten days about normal. Rest of month well above normal (3°-4° on average)	Normal for first three weeks, after which well above normal	First three weeks below normal, last week above.
February	First ten days above normal. Subnormal from Feb. 11-19 to extent of about 2° C.	Normal except for period 14-21, which was decidedly low (7·5° C. on Feb. 15, 7·0° C. on Feb. 16)	Below normal by about 10 per cent.; particularly so during last few days of February and first week of March.
March ..	About normal	Rather cold during first week, otherwise normal	
April ..	Below normal for first half and above during second half	Mostly subnormal	About normal.

The most striking features which emerge from the above are: (1) the unusual highness of the day temperature figures during nearly the whole of the period from sowing to the beginning of picking;

(2) the two cold periods which occurred in the middle of November and the middle of February respectively; and (3) the dryness of the atmosphere during September to November when flowering should have been in full swing, and again during February and March when a large proportion of the bolls were ripening.

This combination of high day temperatures with extreme dryness and occasional short spells of low night temperatures must have constituted an extremely trying environment for the plants, and, combined with the unusually heavy attack of Sudan Bollworm referred to above, might reasonably be considered to account for the observed behaviour of the crop.

PART II.—EXPERIMENTAL WORK, ETC.

(1) Inspection of Cotton Areas.

Two short tours were made in the course of the present season in the rain-grown cotton area, the districts selected being Fung Province and Nuba Mountains Province.

These tours were undertaken partly in connection with the scheme for the establishment of variety-testing stations, and partly with the object of seeing at first hand the conditions under which cotton is growing in those districts.

(*A*) *Fung Province.*—This inspection was carried out during the rainy season, and lasted a little over a week.

By the courtesy of the Governor of Fung Province, I was allowed to make use of the Province steamer, travelling slowly upstream from Makwar to Roseires, and stopping at any places on the way which appeared to be of interest from the cotton point of view. The region traversed included three districts ("merkaz")—namely, Singa, Karkoj, and Roseires. I was able before starting to obtain some figures showing the quantities of cotton seed which had been distributed in these districts during the past two seasons.

The rains of the previous season had been very light, and in consequence there was a shortage of food, the effect of which was shown in the decreased demands for cotton seed. This lack of interest on the part of the natives was also due no doubt to the fact that in many cases in the previous year cotton had been sown in places where, with the low rainfall experienced, the plants withered at an early stage, producing little or no crop.

In Singa "merkaz" some 250 sacks of seed had been used as

against about three times this amount in the previous season; in Karkoj 450 bags had been taken up, about 150 less than in 1925, and in the Roseires district the demand this year had been practically nil. In this last district the District Commissioner was impressed with the necessity for increased food production, and this point of view was doubtless reflected in the area under cotton. In this last district also, it appears that a considerable amount of the cotton which is grown goes over the border to Abyssinia, where it is bought by small native merchants.

Taking the whole area from Sheikh Talha (near Makwar) in the north to Roseires in the south, one finds a steady increase in yearly rainfall from 500 mm. to nearly 800 mm., practically the whole of this falling within the months April to November. The remainder of the year is occupied by a true dry season, when all vegetation dries up and the grass is mostly burnt off.

Practically the whole of the cotton is grown on the black cotton soil, which requires a considerable amount of rain at the beginning of the season in order to put it into a fit condition for the sowing of the cotton. In the dry season this soil bakes out, and becomes excessively hard, with enormous cracks. The baking is, however, beneficial, and it is surprising to observe the loose fine tilth which is obtained after a few heavy showers and without the help of any cultivation. This good working condition is lost as the season progresses and the soil receives more water.

Allowing for this preparatory phase, sowing is usually possible during early to mid-July, and is generally done about that time, which means that the opening of the crop coincides pretty well with the onset of the dry season.

For the most part, the ground rises fairly rapidly on either side of the river for a distance of a mile or less, beyond which it stretches out in a more or less level plain. The level plain is formed by the black cotton soil and the rising ground of the riverside by a light-coloured nodular deposit known locally as "Azaza," which is useless for cotton-growing. In places the cotton soil only reaches a sufficient depth for cultivation at a distance of several miles from the river, the intervening space being filled with trees which become larger and more varied as the rainfall increases. In other places the cotton soil comes right up to the water's edge and may at times be seen in section in the "cliff" where the river is cutting back into the bank.

From the river very little cotton is seen, and the bulk of it is, in fact, grown right inland, sometimes as far as ten to twenty

miles away from the river. The same remarks apply to the Dura crop, which is grown on similar soil and under similar conditions. Several excursions were made into the fringe of this back-country, which, when reached, is all more or less of the same type. More attention was, however, paid to the areas where the cotton soil reached the river's edge. In such places it is usual to find a large cleared area lying just behind the village which is on the bank of the river. Such areas were found at Karkoj, Abu Naama, and Sabonabi-es-sherig. They offer suitable sites for variety tests, as they can be reached from the river at any time during the rains, and present the typical black cotton-soil conditions of growth. The three areas specified appear to be kept more or less permanently clear of big bush, whilst in the hinterland and in other smaller areas encountered near the river bank it appears to be the custom to clear a piece of land, and, after four or five years, to move on to a new site, allowing the first piece to go back to its original condition. At one such place (Shamea Khalil) I was interested to find that the natives regarded the appearance in abundance of a certain weed (*Sonchus sp.*) as a signal to move on to a new pitch.

I have no doubt that a study of the local flora in relation to the suitability of the land for cotton cultivation would yield valuable results applicable to the development of new areas. The major soil differences in the more southerly area were clearly marked by the changing tree-flora, the final transition to the true black cotton soil being almost always accompanied by the dropping out of all trees except the Talha (*Acacia seyal*).

The neighbourhood of Sabonabi-es-sherig was finally selected as a site for two cotton variety tests in the coming season. Here the cotton soil comes right up to the water's edge, and a natural " section " occurs in the cliff-face, which enables one to form an extremely good idea of the subsoil conditions. Photographs of this section were made and soil samples taken. The black cotton soil in this place is typical, but is somewhat lighter than in several other localities, thus favouring the obtaining of a regular stand of plants, so essential in variety-testing work. Sabonabi is about thirty miles south of Karkoj, and the rainfall is in the neighbourhood of 650 mm. and fairly reliable, as evidenced by the growth of " elephant grass," which here begins to reach a fair height, though practically absent at Karkoj and further north.

The following are typical analyses of " black cotton soils " (the actual samples were taken at two places near Singa, and represent the first foot of soil):

Place.	*Stones and Gravel.*	*Coarse Sand*	*Fine Sand.*	*Silt.*	*Clay.*	*Salts.*
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Radina ..	0·7	7·6	13·2	11·9	66·4	·091
Hillet Assar ..	0·0	4·4	10·8	12·4	72·5	·095

At Galgani, a village about ten miles south of Sabonabi, cotton was found growing under conditions quite different from those described above. Here an area of flat "gerf-land," consisting of sandy alluvium of comparatively recent origin, fills a bend of the river. The surface of this flat plain of about 500 acres lies only a few feet above the high-water level of the Nile, and behind it, at a distance of half a mile or so, rises the old bank of the river composed of the typical "Azaza" soil. The population of the village consists almost entirely of West Africans who have settled here either temporarily or permanently in the course of the pilgrimage to Mecca. Their cotton is grown almost entirely on the gerf-land referred to, and is able to draw on subterranean water supplies in addition to the normal precipitation. Sowing had been carried out about two weeks earlier than could be done on the "cotton soil," and the plants when seen were about 35 cms. high, and had for the most part unfolded their eleventh or twelfth leaf. They appeared healthy and quite unaffected by scorching, so prevalent further north. The usual insect and other diseases, including Blackarm, were present, but were not serious. Bud-shedding had taken place to a rather considerable extent, but I understand that useful crops had been obtained in the previous season. It would seem that very good yields might be achieved if the natives gave more attention to cultivation. The plots were for the most part choked with weeds, and thinning of the plants had generally been neglected. It would seem that this type of cultivation might be considerably extended in these regions, as it has the great advantage, as far as cotton is concerned, of ease of transport, and is at the same time partially independent of a somewhat uncertain rainfall. The disadvantages are the excessive growth of weeds and the fact that much of this land is covered with a type of thorny bush (*Zizyphus*) which spreads underground and is extremely difficult to eradicate.

The only competitor in the way of crops is maize, which, when sown early in these situations, produces a good return before the main Dura crops in the inner regions have ripened. This early crop of maize is often very valuable in helping the population to tide over

until the new crop of Dura is ready, but it cannot be denied that this same object could be achieved if the areas of black cotton soil placed under Dura were increased, as could well be done with the present population, given the incentive to a little more industry. In the Roseires district practically the whole of this type of land was under maize, but further north only about one-fifth of the area appeared to be so used.

I attempted to make a very rough estimate of the extent of this gerf-land between Disa in the south and Karkoj in the north, a distance of about ninety miles along the river. Speaking very roughly, there appeared to be something like 10,000 feddans of gerf-land, of which about 3,000 feddans was thickly covered with bush and about 2,000 planted with maize. The remainder, say 5,000 feddans, appeared to be capable of cultivation under cotton, or other crops, without diminishing the present food area. It is probable, however that this area would have to be considerably reduced owing to the landward side of these stretches usually lying low, and in many cases actually filling with infiltration water. Some of the individual areas were large, but generally the cultivable area at each spot appeared to be about 200 or 300 feddans. The largest (estimated) single areas were south of Abu Kuk (say 700 feddans), opposite Abu Zor (say 500 feddans), and opposite Meshra el Khallak (about 700 feddans).

(*B*) *Nuba Mountains Province.*—This is a most promising district for the development of rain-grown cotton, and has been rightly favoured by the Department of Agriculture and Forests in their schemes for the development of cotton-growing. General accounts of the conditions and of the system employed have already been published, so that only a very brief description will be given here.

In general, it may be said that the area consists of an immense plain, composed largely of black cotton soil, from which, like islands emerging from the sea, arise large mountain masses of granite or sedimentary rocks. Around these " islands " spread gently sloping expanses of rock detritus, often for a width of many miles. Frequently, neighbouring mountain blocks are connected either by the confluence of their talus slopes or by low ridges of partially weathered rock. Some of the narrow valleys opening out from the foot of the mountain masses are filled to considerable depth with river-silt. The soil conditions are therefore extremely varied, and it is interesting to find cotton growing and yielding good crops in all these different situations.

The factors of most importance in determining the best cotton-growing areas would appear to be:

(1) A sufficiency of water. Most of the southern part of the district averages about 750 mm. in the year, and is sufficiently well supplied, but a large portion of the northern area does not receive enough to allow of any certainty of obtaining a useful crop in a normal year.

(2) Absence of flooding. Large tracts of the low-lying cotton soil are liable to be permanently under water for two or three months on end.

(3) Absence of undue surface erosion. In many places the heaviness of the individual rain-storms, combined with the steady slope of the land, causes the water to flow over the surface, scouring away the soil as it goes and washing out the growing plants. One of the cotton variety test plots met this fate during the season under consideration, resulting in a loss of about seven-eighths of the crop.

(4) A soil capable of holding water and reasonably penetrable by roots. Apart from this, the actual composition of the soil appeared to be of little importance, and excellent fields were seen both on heavy black cotton soil and on light sandy soils. A reddish-coloured loam containing a fair proportion of gritty sand appeared to be about the ideal where other conditions were suitable.

The trees and other natural vegetation appeared to act as a more or less reliable index of the nature of the soil.

The following is a selection from some soil analyses made for me by the Government Chemist on samples collected in the various areas, and the differences shown are very striking:

Sample No.	*Stones and Gravel.*	*Coarse Sand.*	*Fine Sand.*	*Silt.*	*Clay.*	*Notes.*
	%	%	%	%	%	
J. ..	26·4	47·6	14·7	5·9	5·3	"Gardoud" soil taken from a sloping field right at the foot of a mountain and made up of detritus washed from it. Cotton was excellent.
L. ..	0·0	3·9	11·4	21·4	63·3	Typical dark brown "cotton soil" capable of producing well-grown plants and a satisfactory crop.
M. ..	0·0	2·6	30·6	26·4	40·7	From a field near Kadugli, bearing a very good crop of cotton; reddish in colour with some largish cracks, but much less than in "cotton soil."

My visit to this district was made at the beginning of the third week in November, and lasted about ten days, during which I was able to travel by motor-lorry through the most important cotton-growing areas. The actual itinerary was: Rahad, Rashad, Delami, Heiban, Talodi, Kadugli, Dilling, el Obeid.

No really successful attempts at cotton-growing were seen until Heiban was reached, but excellent fields were seen there and between it and Talodi. At Talodi a detailed inspection was made of a cotton variety test which had been carried out for us by the Inspector of Agriculture. This particular plot was a great success, as far as regularity and growth of the plants were concerned. The most important cotton area is, however, situated round Kadugli as a centre, and here I was able to see several fields of very well-grown cotton. Under suitable conditions the plants had grown extremely well, and only in rare cases was rank over-growth noted. Shedding was as a rule comparatively slight. The normal spacing appeared to be rather wide, and I think somewhat better results would be obtained if the natives could be induced to sow closer. Sowing was formerly carried out rather late, largely with the idea of bringing the whole of the picking season into the dry period of the year. It has been observed, however, that by planting earlier it is possible to escape a portion of the Stainer-bug (*Dysdercus*) infestation, and late June is now considered the best period. An inspection of the rainfall data suggests that this should be about the ideal time, allowing, on the one hand, for the soil to become sufficiently moistened and the first crop of weeds to be cut out, and, on the other, for the bulk of the boll-opening to occur in the dry season, which starts about early November and lasts until about the end of March. An argument for July sowing, however, exists in the occurrence of a comparatively drier spell at that time, enabling sowing to be done in a better manner, and possibly reducing the risk of Black-arm infection.

American-type cotton is at present exclusively grown, and this would certainly appear to be the preferable type in view of the extra susceptibility of Sakel cotton to Black-arm disease, and the slowness of arrival of the crop due to its tendency to "miss-fire" in the lower part of the fruiting-branch zone. The more drawn-out character of the picking period in the case of Sakel would probably result in the loss of a large portion of the latter end of the crop from water-starvation. The seed used is supplied from the Government Pumping Stations on the Nile, and though the yield is satisfactory, the quality and purity of the crop leave much to be desired. The

irregularity in habit of the plants gave plenty of opportunity of selection of types apparently suited to the conditions, and several such selections were made. In general, stems and branches tended to be rather thinner and internodes longer than under conditions of irrigation, and monopodial branching was considerably less abundant. The differences between individual plants appeared to be accentuated here, both as regards vegetative habit and lint characters. Pests were not seen in excessive quantity, but a fair amount of damage to early buds and flowers had been caused by the Sudan Bollworm, followed by the "American Bollworm" (*Heliothis obsoleta*).

Throughout the whole journey observations were made on the state of growth of the plants, and full details entered as to the areas of the different types of soil encountered *en route*, together with a few notes on the trees associated with them.

At Talodi I was met by Mr. G. F. March, to whom the development of this area has been entrusted. From him I obtained details as to the quantities of seed issued and the methods employed for collecting, taking-over, and transporting the cotton. The undertaking has been extremely successful, and the yield from this season's crop amounted to nearly 9,000 large kantars, although a start was only made three years ago. The population is very backward judged by ordinary standards, but has responded very well to the encouragement given. The inhabitants may be expected to make quite efficient cultivators of their class, and, given time and immunity from raids, should soon spread downwards from the hills into the many large and extremely promising areas which lie some distance from the mountains. There is, without any doubt, a very large area of suitable ground awaiting future development.

(*C*) *The Gezira Area.*—As usual, two or three visits were made during the course of the season to the Gezira Research Farm and the Seed Farm of the Sudan Plantations Syndicate. The primary object of these visits was the making of records on the two cotton variety test plots situated at those places, but the opportunity was taken to examine some of the surrounding cotton areas at the same time. One extremely interesting feature was noted, and that was the entirely different behaviour of the cotton on the Gezira Research Farm, compared with the previous year and with former experience in the Gezira area.

The difference lay in the fact that the phenomenon of suppression of the lower fruiting branches was practically absent. Effective fruiting branches were commonly produced in the tenth or eleventh leaf axil of the stem, as against the twelfth to fourteenth axil in the previous

season's crop. This effect was shared by *all* the cotton plots on the Gezira Research Farm, and by *all* varieties (in different degrees) in those plots. The change would not have been considered very remarkable, if it had not been noted that the plants at the adjoining Barakat Seed Farm did not show it. The behaviour there was that of the normal Gezira type noted in last year's report, fruiting branches being produced in the thirteenth to fifteenth axils, or even higher. An examination of the cotton in the neighbouring areas showed that it agreed with the normal Barakat type.

The improvement in appearance of the crop at the Research Farm was very striking, the usual " legginess " being practically absent. This improvement was accompanied by a very much improved yield, and by an entirely different manner of " arrival " of the crop as compared with Barakat.

The variety test plots at these two places agreed entirely with the crops surrounding them, and as they each contained exactly the same series of varieties grown from the same seed and sown on practically the same day, the observations made on them are particularly valuable for comparative purposes.

The first picking at the Research Farm was taken over three weeks earlier, and another quite large picking was made before any cotton had been gathered at Barakat. The third picking at Wad Medani Research Farm was easily the largest, good-sized yields being obtained also from the fourth and fifth pickings. At Barakat the earlier pickings (already late in time of arrival as compared with Wad Medani) were comparatively small, and big pickings were not taken until the fifth and sixth pickings, at a time when the Medani crop was nearly finished.

Only about one-twentieth of the Medani crop was picked in the month of April, whereas nearly a quarter of the whole crop was taken in that month in the case of Barakat, where the plants were of the usual leggy type and lodged badly during the later pickings. The reasons for this difference in behaviour are being investigated, and it is hoped to publish the results at a later date, but it would seem probable that they are connected with the presumably higher moisture content of the soil at Wad Medani, brought about by an extra watering given in the early stages and conserved by more frequent surface-tillage, or possibly by a lower soil temperature or air temperature induced by these waterings. The matter is certainly one of the highest importance to the future of cotton-growing in the Gezira.

Another point of considerable importance was noted in con-

nection with a test which was carried out this season at the Gezira Research Farm between different strains of cotton. Sakel strains from Tokar and Kassala were included this year as last, and observations were made in both years on the relative vigour of the various strains when in the earlier stages of growth. The records in both cases were made " blind " without any key to the individual subplots, and the results have been sufficiently consistent to suggest that they have some significance. In the previous year the subplots sown with Sakel seed from Tokar and from Kassala were evidently the most vigorous: in the present season strains from these places were clearly surpassed in vigour by other strains, including locally grown seed. The reason for this difference is doubtless connected with the fact that both the Tokar and Kassala seed which were supplied this year for the test were immensely superior in the matter of purity to that of the previous year. The apparent extra vigour of the previous year was certainly due, in part at any rate, to the very large percentage of hybrid plants.

(2) Cotton Variety Testing.

The scheme referred to in Appendix B. of last year's report* has been put into effect, and the results obtained appear to be sufficiently satisfactory. I have attached great importance to this side of the work, as I feel convinced that it is waste of time attempting to produce new varieties if we have not the means of deciding whether, when produced, they are an improvement on existing ones. Even in cases where breeding has been carried out with one particular object in view, and that object achieved, it is impossible to say without trial whether the rest of the genetic constitution of the plant has not been altered in some direction which will be actually deleterious as regards yield.

The technique of variety testing in general is beginning to be understood, and it is now usual to make use of the standard error of the differences between varieties in deciding the degree of reliability of the results obtained. It cannot, however, be too strongly emphasized that these mathematical criteria are based on the law of chance working within a large population. In the case of variety tests, repetitions of each of the types in different parts of the field are essential if any useful results are to be obtained, but it is impossible in practice to work with such a number of repetitions as will be sufficient to avoid absolutely the danger of a misleading value being obtained.

* Reports received from Experiment Stations 1925-26, published by the Empire Cotton Growing Corporation.

Furthermore, results which are apparently statistically significant in one plot may be contradicted by those obtained from another plot. Yield figures alone will be of little assistance in helping us to decide in this case which of the varieties is most likely in general to succeed.

With these considerations in view, an attempt has been made to keep a *developmental record* of the plants in the variety tests, in order that some information may be available to act as a check on the accuracy of results obtained, and to assist in explaining the differences noted. This work takes up a very considerable amount of time, both in the collection of the data and in the process of working up the results, but it is so important that no excuse need be made for embarking upon it. At the present time practically no information is available to cotton workers as to the connection between the various developmental characters and the final yield, so that it remains to be seen how far this line of research will yield the information hoped for.

The area in which cotton is grown in the Sudan is a very extensive one, and the conditions of soil and climate under which the plants live cover a very wide range. It has therefore been necessary to establish a *series* of testing stations in different parts of the country in order to gain information as to the behaviour of the varieties under the varying conditions. The distance between these plots and the slowness of transport makes the taking of developmental records additionally difficult, and the impossibility of supervising picking operations in two places at the same time necessitates that the layout of the plots should be as simple as possible.

The final scheme adopted, therefore, is in the nature of a compromise between full accuracy of the individual plot and wideness of applicability of the results obtained. The tests are divided into two series, one being concerned with *Egyptian-type* cottons grown under conditions of irrigation, and the other with *American-type* cottons under both irrigation and rainfall conditions. In each series a standard layout was adopted with subplots of similar size and shape, and the varieties tested were the same in each case.

The number of varieties tested in the more easily controlled Egyptian cotton areas was six, the total area of the plots being 5 feddans, but in the case of the American tests, some of which had to be carried out in places far removed from railways and quick transport, the number of varieties has been restricted to five. In the case of the more accessible American variety plots situated in the northern irrigation zone, the area of each plot has been fixed at 5 feddans, but that of the distant plots in the rain-grown areas has been kept down to 3 feddans only.

The number and arrangement of the test plots carried out this year are as follows:

(*A*) Egyptian Varieties.—(1) *A single plot* at Shambat, situated in the general cultivated area, not far from the Experimental Farm.

(2) *A single plot* at Wad Medani, carried out by the Chief Inspector, Gezira Research Farm, on their land.

(3) *A single plot* at Barakat, carried out on the Seed Farm of the Sudan Plantations Syndicate by the Manager of the Seed Farm.

(*B*) American Varieties.—(1) *A single plot* at Kober, on the estate of M. Aziz Kfouri, situated about three miles from the Experimental Farm at Shambat (irrigated).

(2) *A pair of plots* near Shendi, on land belonging to the Government Pumping Station at Gendettu (irrigated).

(3) *A pair of plots* near Singa, carried out under arrangements made by the Inspector of Agriculture, Makwar, on land rented from native cultivators (rain-grown).

(4) *A pair of plots* near to Talodi, carried out by the Inspector of Agriculture, Talodi, on land rented from native cultivators (rain-grown).

The actual situation of these ten plots, and their relation to the surrounding cotton areas which they represent, as well as to the distribution of rainfall, can be gathered from an inspection of the accompanying sketch map.

It is not proposed to enter into details with regard to the arrangements made for the carrying out of agricultural operations, including picking, etc., but hearty thanks are due to all those outside the Plant Breeding Section who have assisted in the work.

In the case of the plots at Wad Medani and Barakat the ginning of the seed cotton has been carried out locally under arrangements made by the officials in charge of those stations: in all other cases the seed cotton has been transported to Shambat, and ginned out by the Plant Breeding Section at its own ginnery. In all cases any seed cotton taken from the plots for sampling purposes has been ginned out at Shambat for the sake of uniformity. As regards the plots themselves, these are in all cases rectangular in shape, and about three to four times as long as broad. Each plot is divided into five portions, and each of these five " blocks " is itself divided into a number of long, narrow strips which constitute the individual beds sown with the different varieties. All the varieties are represented in each of the five blocks, but the order in which they occur in the strips making up those blocks is different in every case, thus

minimizing errors due to progressive changes in fertility across the field.

In those plots where five varieties are being tested five times, the varieties are so arranged that no variety occupies the same relative position within the block more than once.

It is not claimed that this arrangement of varieties in long narrow strips will give results which are any more accurate than those obtained from the conventional chequer-plot, but it *is* claimed that the accuracy will be practically the same, whilst the simplification in all respects as regards laying out, sowing, and picking will be very great, and purely accidental errors will thus tend to be eliminated.

As regards accuracy, it stands to reason that when two adjacent plots, long and very narrow in shape, are being compared, the comparison will be very much closer than when two adjacent beds of the same area, but square in shape, are used. The narrowness of the strips means that the centre-lines of the two beds are very close together, and the length means that each bed will tap a considerable number of different soil patches, giving a steadier average result per bed as a consequence. This is borne out by results previously obtained by Mr. Trought and myself in Egypt, where it was found that the standard error of a single plot of cotton of long narrow shape was less than that of a single plot of square shape. The same series of experiments indicated that the best results should be obtained by making the area of each subplot between $\frac{1}{10}$th and $\frac{1}{5}$th feddan. The areas actually employed in the different series in the present case varied from $\frac{1}{5}$th to $\frac{1}{7}$th feddan, but were kept constant within those series.

As regards developmental observations the following list indicates the type of records made in the more accessible plots. The significance of these records and the special methods employed for obtaining them will not be gone into in detail in this report, as it is hoped to publish a separate paper dealing with this subject, if the results obtained appear to warrant it.

Environmental and Developmental Records in Cotton Variety Tests.

1. *Soil conditions*, as indicated by samples taken from every subplot and analyzed by the Government chemist.
2. *Germination*—record of blank spaces, etc.
3. *Resowing*—amount of seed used in each bed.
4. *Final stand*—an actual count of plants.
5. *Weediness.*
6. *Early and late vigour.*
7. *Early height and final height.*
8. *Rate of node production on main stem and along branches.*

9. *Position on stem of lowest part of fruiting zone.*
10. *Shedding.*
11. *Flower-production.*
12. *Incidence of pests* of all kinds, including Black Arm disease.
13. *Serial yield records*—the final yield being composed of from seven to nine separate pickings.

Results from Egyptian Variety Test Series.

Unlike the American Variety Series, which, as will be seen later, gave very similar results in each of the localities where the crop had been grown under irrigation, the results in the present series are very conflicting.

All three plots (Shambat, Wad Medani, and Barakat) were sown on almost exactly the same date (August 14th to 18th), and efforts were made to keep the layout and arrangement of the plots as nearly as possible identical. Owing to a misunderstanding, the relative position of the variety beds in the Wad Medani plot was different from that at the other two places.

The marked difference between the neighbouring plots at Wad Medani and Barakat in the matter of arrival of the crop has already been dealt with under the heading of " The Gezira " (p. 155).

The plot at Shambat agreed with that at Barakat as regards the date of the first picking, but the pickings throughout were low and the final yield very poor. (See Introductory Notes on pp. 143-144.)

The relative position of the varieties in order of yield in individual pickings shows great instability in the three plots, and the final results are almost equally discordant.

In the table on p. 162 the varieties in each plot are shown in descending order of merit as regards yield, together with their mean bed yields and standard error of mean difference.

(The standard error for Barakat has not been included owing to the extra irregularity shown by the soil in this plot.)

It will be seen that in all cases the varieties stand very close together in the matter of mean yield per bed, and comparison with the standard errors of mean difference will show that even the two extremes in each case do not lie sufficiently far apart to be " significant."

Notwithstanding this, it may be possible to come to a few general onclusions.

Shambat.—Here the stand of plants was rather irregular, and one bed of Sakel B/24 showed very poor germination indeed. The effect is clearly discernible in the yields of the first two pickings.

A detailed examination of the distribution of individual bed-yields

in space and time (method of working too lengthy for description here) shows, however, that the effects of this irregular germination and of soil balance out pretty closely in the long run as between varieties. The only exception would appear to be Nahdah, which has perhaps gained 2 to 4 rottles in mean bed value through the agency of such external factors. If this very speculative correction be applied it would only have the effect of bringing Nahdah and Bolland Sakel 8 closer together, the order of the rest remaining unchanged.

EGYPTIAN VARIETY TEST SERIES.

SHAMBAT.		BARAKAT.		WAD MEDANI.	
Yield per Feddan for Plot =1·5 Large Kantars.		*Yield per Feddan for Plot =4·05 Large Kantars.*		*Yield per Feddan for Plot =4·2 Large Kantars.*	
Varieties.	*Mean Bed Yield.*	*Varieties.*	*Mean Bed Yield.*	*Varieties.*	*Mean Bed Yield.*
	Rottles.		*Rottles.*		*Rottles.*
Nahdah ..	85·6	Sakel 186 ..	222·0	Sakel 186 ..	242·0
Bolland Sakel 8	83·1	Bolland Sakel 8	217·8	Main Crop Sakel	225·2
Massey's Domains Sakel	81·9	Massey's Domains Sakel	217·6	Massey's Domains Sakel	223·8
Main Crop Sakel	77·1	Sakel B/24 ..	213·2	Sakel B/24 ..	222·4
Sakel B/24 ..	77·0	Main Crop Sakel	208·2	Bolland Sakel 8	213·2
Sakel 186 ..	76·6	Nahdah ..	198·6	Nahdah ..	212·0
Standard error of mean difference =	2·72	Standard error of mean difference =	—	Standard error of mean difference =	11·371

BARAKAT.—In this plot the state of affairs as regards the incidence of accidental factors affecting regularity was much less satisfactory.

Two large patches of specially strong growth occurred, but were fortunately nearly limited to whole "blocks" in each case. The effect was not, of course, equally intense all over these patches, and this fact, combined with the existence of smaller irregularities (one affecting three beds), has produced "accidental" differences between the plots, which do not appear to balance out very well. An investigation of the data suggests that these accidental errors might be estimated (very approximately) as causing the mean values obtained to vary by the following amount from the true values:

Massey's Domains Sakel affected adversely to extent of, say, 4 rottles on mean value.

Bolland's Sakel 8 affected adversely to extent of, say, 3 rottles on mean value.

Gezira Main Crop affected adversely to extent of, say, 2 rottles on mean value.
Sakel B/24 affected adversely to extent of, say, 1 rottle on mean value.
Sakel 186 affected favourably to extent of, say, 1 rottle on mean value.

These corrections, if justified, would put Sakel 186, Bolland Sakel 8, and Massey's Domains at almost exactly the same level. Sakel B/24 and Main Crop would be bracketed together at a slightly lower figure, and the position of Nahdah would remain unchanged.

It may be noted that the above-suggested corrections allow also (very roughly) for the estimated effect of irregularity of stand of plants in the different beds. Irregularities in stand produced a quite clearly marked effect on the yields obtained during the second to fifth pickings in this plot.

Wad Medani.—The stand here was fairly satisfactory. The plot was rather clearly divided into an area of high vigour (Beds 2 to 15) and an area of low vigour (Beds 17 to 31, decreasing rapidly in the last few beds). Despite this, irregularities appear to have balanced out very satisfactorily on the whole, though Massey's 186 and Main Crop Gezira may both have been penalized to the extent of not more than one rottle off their mean yields.

It will be seen that the application in this way of " corrections " to the three plots has done little to assist in placing the varieties in their correct order of merit, and it may be taken that they do in fact show no very important difference in the matter of yield. A guess may perhaps be hazarded that Sakel B/24 and Main-Crop Gezira are rather on the low side as regards yielding power, whereas Bolland Sakel 8 and Massey's Domains tend to be higher. As regards Nahdah and Sakel 186, it seems likely that, under the better environmental conditions obtaining at Wad Medani and Barakat, Sakel 186 is capable of setting a bigger crop than any of the others whereas Nahdah is the worst. Nahdah, however, may be postulated to have a better defensive organization, and under the adverse conditions experienced at Shambat the position is reversed.

A point of particular importance which emerged from our data was the relative susceptibility of the different varieties to *Blackarm*. The six varieties showed the same order at each of the three stations, and we are therefore able to make the following statement with considerable confidence:

Least susceptible	Nahdah.
Next least	Bolland 8. Main Crop (Gezira). Sakel 186.
More susceptible	Massey's Domains.
Most susceptible	Sakel B/24.

This information, combined with the indication obtained of low yielding power, suggests that Sakel B/24 should not be used for widespread propagation in the Gezira area. Massey's Domains, being also on the susceptible side, should be tried only with caution in areas subject to the disease. It may perhaps be remarked that the attack in this particular year was relatively light all round, and our yield curves appear to show no differential effect due to this cause. The following further general characters would also appear to be established for the varieties examined:

Nahdah.—Rather lacking in vigour, and the rate of node production in early stages is slow. The bottom of the fruiting branch zone is definitely nearer the ground (by about two nodes) than is the case with the other varieties. The earliness which this latter characteristic might be expected to produce is considerably offset by the slow rate of node production. Nahdah lodges worse than any of the other types tried.

Sakel 186.—Rather lacks vigour. Tends to produce rather good early pickings, due probably to a quick rate of node production in the early stages, and to a tendency to put out its fruiting branches at rather earlier nodes than in the other Sakels tried. Growth of monopodial branches is moderate in quantity. The variety is quite satisfactory as regards lodging.

Massey's Domains Sakel.—This type is more vigorous than the foregoing, but it tends to be latish in the matter of production of fruiting branches, a fault which is probably offset by a fairly rapid rate of nodal development in the early stages. Some indications were obtained that shedding was less pronounced in this variety than in some. A slight tendency to show resistance to Thrips and Flea Beetle was noticed at one place. Growth of monopodial branches tends to be slight. This type gave a good average yield in all three localities, and would be satisfactory if it were not for its apparent tendency towards susceptibility to Blackarm.

Sakel B/24 appears to be naturally rather lacking in vigour, and, as previously stated, would certainly seem to be more susceptible to Blackarm than any other of the varieties tried. Its yield is on the low side in all places, and if the trials in the coming season confirm these tendencies it will be abandoned. Early node production is rather rapid, and the first sympodial branch is usually borne at a somewhat lower node than in the average Sakel in this country. It appears to be rather susceptible to Thrips and Flea Beetle. Considerable variation was shown between the different plots in the matter of both monopodial branch production and degree of liability to lodging.

Bolland Sakel 8.—This is the most vigorous growing of the types tried. Nodes are laid down rapidly in the early stages, but the first fruiting branches generally appear late and high up on the stem. On the whole, the variety seems to show indications of some slight power of resistance to Thrips attack, and this, combined with its comparatively low susceptibility to Blackarm, might make it a useful standby in regions where these pests are serious. The variety was satisfactory on the whole as regards lodging. Degree of production of monopodial branches is variable, but usually on the light side.

Main Crop.—This type, which came from seed supplied by the Sudan Plantations Syndicate from the crop grown in 1925–26 at Wad Sulfab, was included in the series for comparative purposes. In yield it occupied a more or less average position at each of the three places. It showed considerable natural vigour and rather rapid early node production, but was definitely unsatisfactory in the delay shown in producing fruiting branches, and appeared to shed rather heavily. It produces rather too much early monopodial branching, and has a decided tendency to lodge badly. It is fairly susceptible to Blackarm, but is perhaps slightly resistant to Thrips.

All the above varieties will be tried again in the coming year, and arrangements are being made for spinning and grading tests and measurements, the results of which are needed for consideration at the same time as the yield figures, in order to make it possible to form some idea of the relative *value* of the varieties to the grower.

Results from American Variety Test Series.

Only four out of the seven plots laid down gave results worth recording. The other three were all situated in areas where they were dependent upon rainfall only for their water supply. Two of these latter plots, situated near Singa, never received enough rain to produce a crop, whilst the third, one of a pair near Talodi in the Nuba Mountains, received so much that practically half the plants were washed out.

Of the four surviving plots, one was situated at Kober, two others near Shendi, and the fourth near Talodi, where it escaped the fate of its companion plot. The results are tabulated on page 166, the varieties in each case being shown in order of merit as regards yield.

Compared with their standard errors of mean difference, the mean bed yields barely show different disparity to enable any except the two extreme varieties in each case to be considered as " significantly " different from the statistician's viewpoint.

AMERICAN VARIETY TEST SERIES

Irrigated Plots.						Rain-Grown Plot.	
Kober.		Shendi (Plot I.).		Shendi (Plot II.).		Talodi.	
Yield per Feddan=2·8 *Kantars* (*Large*).		*Yield per Feddan*=2·6 *Kantars* (*Large*).		*Yield per Feddan*=3·1 *Kantars* (*Large*).		*Yield per Feddan*=2·1 *Kantars* (*Large*).	
Varieties.	*Mean Bed Yield.*	*Varieties.*	*Mean Bed Yield.*	*Varieties.*	*Mean Bed Yield.*	*Varieties.*	*Mean Bed Yield.*
	Rottles.		*Rottles.*		*Rottles.*		*Ro*
Pump Scheme Strain	205·5	Pump Scheme Strain	190·1	Pump Scheme Strain	209·1	Pedigree Dixie ..	84·2
Pedigree Dixie ..	189·8	Webber 38	173·0	Pedigree Dixie ..	206·7	Delta Webber No. 1	79·0
Massey's Selected Gendettu	182·8	Massey's Selected Gendettu	168·5	Webber 38	194·4	Massey's Selected Gendettu	4
Webber 38	155·6	Pedigree Dixie ..	152·4	Massey's Selected Gendettu	185·0	Pump Scheme Strain	75·2
Delta Webber No. 1	149·1	Delta Webber No. 1	149·5	Delta Webber No. 1	170·3	Webber 38	72·8
Standard error of mean difference = 23·92		Standard error of mean difference = 10·9		Standard error of mean difference = 10·9		Standard error of mean difference = 3·62	

Note.—Of the two plots at Shendi, Plot I. was sited on typical lightish alluvial soil of comparatively recent origin underlain by a sandy stratum, whilst Plot II. was on a type of soil known locally as "Karu," containing about the same proportion of clay in the upper layers, but much heavier to work and only *gradually* passing to a lighter soil below.

The Kober plot was situated on soil very similar to that of Shendi (Plot II.).

The rain-grown plot at Talodi was sited on a rather heavy loamy soil, overlying a lighter subsoil composed largely of decomposed granite

The three plots grown under conditions of irrigation, however, all show a close resemblance between themselves, in the order of yield of the varieties, sufficient to enable one to form a very fair idea of their relative yielding power under the conditions obtaining for the year in question. This resemblance between the plots is not confined to the final yields, but can be traced to some extent at any rate in the partial yields given at different stages of the picking season, a fact which affords further evidence for considering that it is not merely fortuitous.

As regards the plots themselves, that at Kober suffered considerably in the matter of irregularity of watering, due to mechanical trouble with the pump at that place. This is probably reflected in the greater range of variation in yields shown by individual varieties.

Germination and stand of plants were reasonably regular, but the irregularities which did occur would appear to have affected the final yields to some extent. It would seem that the varieties Delta Webber and Massey's Gendettu may have been slightly penalized by comparatively poor stand. The same two varieties, and also to a less extent Pump Scheme Strain, were probably rather unduly adversely affected by the irrigation difficulties referred to above.

Shendi (Plot I.) showed very irregular germination in some cases, and the effect of this was clearly observable in the results from the first few pickings. Later, when the roots reached the underlying sandy stratum, the growth became very rank, and the influence of irregular spacing was entirely masked. On the whole it would seem that Pump Scheme Strain and Webber 38 were rather favoured by this irregularity, and this possibly accounts for the relatively higher position of Webber 38 in the matter of yield in this plot.

Shendi (Plot II.) showed even more irregular germination, as the result of which large bare spaces were left in some of the beds. The "scatter" arrangement of the beds, however, was rather successful in equalizing out the effect, and it is probable that no particular variety was specially penalized. If anything, it would seem that Pump Scheme Strain and Webber 38 had been slightly favoured. This equalizing effect of bed-scatter was particularly useful in this case, as the effect of the blank spaces was very clearly observable in the yields of individual beds throughout all pickings, and would have been disastrous if it had been limited to one or two varieties only.

With the above considerations in mind, it is now possible to return to the results shown for the irrigated plots, a

draw more definite conclusions as to the relative position of the varieties.

The final order of merit (*for yield only*) for these varieties in the northern Sudan during the present season would appear to be as follows:

1. Pump Scheme Strain.
2. Pedigree Dixie.
3. { Webber 38.
   { Massey's Selected Gendettu.
4. Delta Webber No. 1.

This order is based upon (1) the averaged results of all three plots, and (2) the detailed information available *re* germination, stand, etc., which is summarized above.

This ability to make a definite pronouncement on the relative performance of these varieties, in spite of plot irregularities and in the face of comparatively high standard errors, is very pleasing, especially in view of the very considerable time and labour involved in the compilation of the detailed records and in the process of reducing the data to usable form. It is very much to be hoped that the staff may be suitably strengthened in the coming season, in order to enable this line of research to be pursued and further extended.

The relative *value* of these types to the grower remains to be determined from a joint consideration of yield and spinning quality.

Samples of all these types are being submitted to the British Cotton Industry Research Association, but their reports on spinning quality, etc., will not be available for some months. For the present it is sufficient to note that the Pump Scheme Strain, Webber 38, and Massey's Selected Gendettu fall within the class of average Long Staple American, whilst Delta Webber is particularly long and fine, and may be expected to command a very useful premium. Pedigree Dixie, on the other hand, whilst still within the long-staple class, is decidedly shorter and rougher in character than the other cottons in the series.

The Talodi Plot results have not so far been touched upon in this discussion, and are very interesting in that they differ very markedly from those obtained from the irrigated plots (see table of yields above). The plot itself showed a reasonable degree of regularity as regards stand of plants, except for certain differences in the number of plants per row, and for one or two patches where plants had visibly suffered from waterlogging or had even been washed bodily out of the ground.

The plot records here are very scanty, due to the inaccessibility of the plots, but the information available suggests that Delta Webber has been to some extent penalized by waterlogging, and that the first picking of Pedigree Dixie was materially reduced by the washing out of seedlings. The final order would therefore appear to remain unchanged.

The appearance of Delta Webber No. 1 nearly at the top of the list in this case is doubtless connected with the curtailment of the picking season by drought, which normally occurs in these parts as a result of the cessation of the rains. This variety characteristically produces a heavy early crop, but, under irrigated conditions, is not capable of the same sustained effort which is shown by the other varieties. This earliness is in turn connected with a tendency in this type to produce its first fruiting branch on the average one node sooner than the other varieties.

The relatively poor behaviour of the Pump Scheme Strain was apparently due to a higher degree of shedding under the particular conditions of growth at this place.

The good performance of Delta Webber No. 1 is especially noteworthy in view of the high quality of lint referred to above. Another feature which may perhaps make this variety specially suitable as a rain-crop is the tendency shown by open bolls to hang downward, thus minimizing the risk of damage by rain to the cotton whilst still on the tree.

The following notes on the special characteristics of varieties are based on observations in irrigated areas only.

Pedigree Dixie.—Production of fruiting branches begins low down on stem. Shedding is not very high compared with other varieties. More resistant to Blackarm than other varieties in the series. Lodges very badly.

Delta Webber No. 1.—Fruiting branches produced particularly low down. Rather susceptible to Blackarm. Sometimes inclined to lodge, but the short growth of the stems prevents serious entanglement.

Massey's Selected Gendettu.—Starts rather late in matter of fruiting branch production. More susceptible to Blackarm than others in this series. Not very inclined to lodge.

Pump Scheme Strain.—Similar to the last in matter of fruiting branches and lodging. Slightly less susceptible to Blackarm, but probably second worst in this respect.

Webber 38.—Apparently tends to be rather late in production of lowest fruiting branch. It shows average resistance to Blackarm. Upright habit, with stiff stem and very little tendency to lodge.

Preliminary Variety Test.

In addition to the above two "standard" series of variety tests, one other strip test was carried out on similar lines on the Experimental Farm at Shambat. The types tested were mostly new kinds, of which only a little seed was available, and the test was made to enable a preliminary weeding-out of undesirable sorts to be carried out.

The developmental records on this plot were particularly full owing to the ease with which it could be reached from the laboratory, but as the final yield results are of little general interest at this stage, only a very brief summary will be given.

The stand throughout the plot was very satisfactory, but soil irregularities were troublesome, and an attempt has been made to allow for these. The actual final yield results are summarized in the following table, the varieties being arranged in descending order.

Preliminary Variety Test. Shambat Experimental Farm.

Average Yield per Feddan = 1·2 *Large Kantars.*

Varieties.	*Mean Bed Yield.*	*Standard Error of Mean Difference.*
S.I.D. 18	83·8 rottles	7·65
N.T. 25/24	71·4 „	
S.I.D. 14·1	66·2 „	
S.I.D. 3·2	65·4 „	
Massey's Selected Domains	59·4 „	
Garofallou	59·0 „	
S.I.A. 2·7	47·2 „	
S.I.A. 7·1	40·4 „	

Corrections for soil irregularity suggested by our records would apparently leave the order unchanged, but would improve somewhat the figures shown for N.T. 25/24 and S.I.A. 2·7.

The variety known as "Massey's Selected Domains" is the type which is grown in bulk on the Experimental Farm, and was introduced into the series as a basis for comparison.

The relatively high yields of some of the varieties are doubtless due to some extent to their hybrid nature.

N.T. 25/24 is an Upper Egyptian type and extremely early compared to the rest, its earliness being definitely connected with a very rapid rate of node development in the early stages accompanied

by the power of producing fruiting branches at a very low node of the stem.

In S.I.D. 18 the fruiting branches also start comparatively low down, and shedding is not more than medium.

S.I.D. 14·1 is very similar to S.I.D. 18 as regards the above characteristics.

S.I.D. 3·2 tends to produce its first fruiting branches rather later, but shedding is on the low side.

As regards degree of Blackarm infection the standard type (Massey's Selected Domains) appeared to be the worst, followed by S.I.A. 7·1. The infection was in all cases slight in the present season. The extra degree of infection shown by the Massey's Selected Domains may perhaps be connected in part with the additional chances of seed infection which must have occurred in this case, as the variety has now been grown at Shambat for a number of years.

S.I.D. 18 showed markedly superior vigour to the other varieties in the plot.

(3) Pedigree Line and New Selection Plots.

An outline of the methods employed has already been given in last year's report, and the significance of the terms " New Selection " and " Pedigree Line " explained.*

In the present season the following types were dealt with:

Egyptian " Uppers "	21 New Selection families.
Sakel (Egyptian)	10 Pedigree Line families.
Afifi (Egyptian)	1 Pedigree Line family.
Sea Island	35 New Selection families. 89 Pedigree Line families.
American	31 N.S. families. 44 P.L. families.

In order to avoid as far as possible the danger of outcrossing between the American cottons and the Egyptian types which constitute the main crop of the farm, the American families were segregated in a small area well away from the rest. Sowing was carried out between July 8-11, and the stand was on the whole satisfactory, though considerable losses were sustained at a later stage from the attacks of the larva of the Stem Borer beetle.

The methods employed in making observations in the field were similar to those of last year. It has been found possible, however,

* See Reports received from Experiment Stations 1925/26, pp. 125 and 130

to extend the laboratory records so as to give more complete information. The following points were dealt with in the laboratory:

Yield of seed-cotton.
Yield of seed (natural and self-bred).
Halo length.
Regularity of length of hairs (vertical and tangential).
Fineness, " toughness " and lustre of fibres.
Fuzz characters of seeds.
Ginning out-turn (percentage).
Weight of 100 seeds.
Lint index.
Hair-weight per centimetre.

The following very brief notes are given with reference to the families shown above in the same order as that in which they occur in the list.

Egyptian " Uppers " (N.S.).—All these families were extremely early compared with any other families in the Egyptian and Sea Island Plot, and this extra earliness was definitely associated with a " fruiting zone " situated low down on the plant axis. The first fruiting branches were usually produced from the eighth or ninth axils of the stems. For the most part, these families were low-growing, and were more affected by drought than the other types. This tendency to " thirstiness " was later found to be connected with a root system well developed in the upper layers, but with little power of vertical penetration.

The families grown represented two different types of Upper Egyptian—viz., a selected Ashmuni and a new type known as " N.T. 19/24." The latter type proved to be very similar in behaviour here to the Ashmuni, but was a trifle later, and the average lint length (halo) came out at about 29 mm. instead of about 27 mm. Yields on the whole tended to be rather bigger than those obtained from Sakel P.L.'s. Final selections were made as follows for sowing next year:

Ashmuni	.. ..	5 plants for P.L. (Pedigree Lines). 3 plants for N.S. (New Selections).
N.T. 19/24	.. ..	8 plants for P.L. 1 plant for N.S.

Sakel (P.L.'s).—All these families were late and " leggy," and the lowest fruiting branches rarely appeared before the twelfth to fourteenth axil. One family derived from " Sakel 176 " gave a satisfactory yield, and was reasonably pure. The halo-length in this case was round about 35 mm., and the ginning outturn and lint index, as well as quality of lint, were satisfactory.

Final selections were made as follows:

From "Sakel 176" derivative	4 plants for P.L.
From other Sakel families	5 plants for N.S.

Afifi (P.L.).—Only one family had been grown from this stock, but the results obtained in the matter of earliness and yield were sufficiently encouraging to warrant further selections being made. The halo lengths came out about 28 to 35 mm., the family being apparently not pure in this respect, as also in the matter of flower colour and degree of monopodial development.

Selections made	3 plants for P.L. 1 plant for N.S.

Sea Island (N.S.).—These families were grown from single plants picked out of the small plots of Sea Island at Shambat in the previous year (Types A, B, C, and D). They mostly showed hybrid origin, and were unsatisfactory in other respects.

Only five plants were selected (for N.S.'s.).

Sea Island (P.L.).—Out of the total of eighty-nine families, ten were grown from plants selected from families growing at Shambat in the previous season. Of these only two families proved to be worth considering. These were derived originally from single plants introduced from Egypt, where they had undergone previous acclimatization. Both had failed to produce any bottom-crop, and in consequence were tall and leggy, but the top-crop was decidedly heavy, and the quality of the lint fair, but lacking in strength. Compared with the Sakels, their performance here was satisfactory.

The remaining seventy-nine families in this plot were grown from seed supplied by Mr. L. H. Burd from his breeding plots at St. Vincent. Mr. Burd at the same time very kindly supplied details as to the origin and nature of the varieties sent, and the results have proved decidedly interesting. The seed sent included several different original types, often widely distinct in vegetative habit, but in general the growth of the plants compared very favourably as regards general vigour and yield with the Sakel families grown in the same plot. The quality of the lint, as was expected, was not up to Sea Island standards, but this is not considered to be a drawback, provided that it falls within the range of Sakel cotton, which it might conceivably replace.

The most satisfactory type-groups were those which derived their origin from Burd's "AN" (our families 22/26-41/26), "AE" (our families 42/26-51/26), "BD" (our families 55/26-57/26), and GX. 12 (our families 61/26-90/26). All families bred very true, considering the upsetting influence of their transference to Sudan conditions.

Some groups were unsuitable in habit of growth to our conditions, as for instance the " A.J." group, which was definitely procumbent in its growth. Practically all the families were superior to Sakel in the comparatively low position of the first fruiting branches. These branches, however, usually showed very heavy shedding. Despite this the zone where bolls are formed *and retained* was characteristically lower than in the Sakels, and the later top-crop was also usually heavier. On the whole, the plants were more vigorous, less leggy, and much less inclined to lodge than the Sakel families. Good stands were usually obtained, and the effect of scorching winds was rather less marked than in Sakel. The above remarks apply to all groups in general. The following additional notes bring out some of the special features shown by individual groups:

Group A.N.—Monopodial growth is strong compared with Sakel, but usually contributes to the crop. Halo length variable, mostly about 37 mm. Late. Yields quite good. Quality barely up to good Sakel in most cases.

Group A.E.—Some plants managed to set quite a lot of bolls on their lower branches. Halos varied from 37 to 41 mm. Axillary bolls were frequently produced, and shedding was rather less than in most families here. Yields were fair.

Group B.D.—Distinct from most other families in showing very slight development of monopodial branches, and in retaining their first foliage leaves for a longer period than most. Like other groups the plants were late. Halos similar to A.E. Group. Yields fair. Quality rather good.

Group G.X. 12.—Contained several subtypes. One type was markedly tall with long fruiting branches, and gave good yields of cotton of quite good quality. The ginning out-turn and lint index were also satisfactory. Another type was noted as especially vigorous, with rather less shedding than in most cases, and was found to have lint of satisfactory quality (halo 37 to 41 mm.).

Final selections were made from the above groups as follows:

Sea Island from Egypt	3 plants for P.L. 1 plant for N.S.
Sea Island. Burd's " A.N."	21 plants for P.L. 1 plant for N.S.
" " " " A.E."	6 plants for P.L.
" " " " B.D."	7 " " P.L.
" " " " G.X. 12"	19 " " P.L.

In all the Groups referred to above, a tendency was noted for the bolls to open badly. This same tendency had been observed in

other Sea Island families in the previous year and would appear to be characteristic, but from experience with this variety in Egypt it seems probable that some improvement can be effected by selection. Some of this faulty opening may be attributed to defective pollination, and there is reason to think that the receptive surface of the stigmas was actually damaged by heat in the case of flowers which opened during the hot weather in September. Bolls formed during that period were frequently asymmetrical and "tip-tilted," due to the partial or complete failure of the ovules to develop in one or more loculi.

Another factor of great importance is obviously the extent of damage by bollworms, but here a detailed examination of two families, one Sea Island and the other Sakel, appeared to show that the Sea Island was, if anything, rather less affected by these pests than the Sakel.

A noticeable feature in connection with the bolls of Sea Island cotton was the development of a dark red pigment on the outside of affected bolls. This red pigment was almost always observable in cases of bollworm damage, but frequently occurred when bollworms were not present. Its development was certainly connected with the incidence of light, as it rarely developed in situations where the surface of the boll had been protected from the light by overlapping bracteoles. It seems probable that it may be a direct "sunburn" effect, to which the tissues are rendered more liable when damaged by bollworms or other insects. There is a general tendency for these reddened patches to become prematurely dry and hard, with the result that the affected valves are unable to open properly. This reddening, whatever its cause, is much more prevalent in the case of Sea Island bolls than in Sakel bolls, and in the particular case examined it was found that the percentage of *pickable* bolls was about 10 per cent. less in the case of the Sea Island family. This question will receive further study in the coming season. A comparison of the behaviour as regards length and fineness of lint of the Sea Island strains, when brought from St. Vincent to the Sudan, has given interesting results. The table on p. 176 shows the results of detailed examinations made on eighteen different plants belonging to seven different families, compared with the figures supplied by Mr. Burd for the group values of these characters.

An inspection of this table shows at once the remarkable reduction in length of the fibres, even allowing for differences in the method used for determination. The hair-weight per centimetre figures (taken here as a measure of fineness), as determined at Shambat,

St. Vincent.			Shambat.		
Reference Number of Strain.	*Halo Length (Mm.)*	*Hair Weight per Cm. (Mgm.)*	*Reference Number of Family and Plant.*	*Halo Length (Mm.)*	*Hair Weight per Cm. (Mgm.)*
A.N. 25, 25, A. 10 ..	50·3	·00119	23/26 18	37·4	·00156
			„ 20	37·6	·00163
			„ 22	37·3	·00151
A.N. 25, 26, E. 9 ..	50·3	·00119	41/26 17	39·5	·00173
			„ 18	40·1	·00117
			„ 23	39·0	·00144
A.E. 25, 27 (26) ..	52·0	·00116	43/26 3	40·4	·00118
			„ 4	40·1	·00138
			„ 5	39·6	·00101
G.X. 12. 25, 32, A. 14..	50·9	·00101	61/26 9	38·5	·00163
			„ 13	40·0	·00104
			„ 22	37·5	·00126
G.X. 12. 25, 34, E. 4 ..	50·9	·00101	75/26 17	39·8	·00112
G.X. 12. 25, 35, A. 11	50·9	·00101	76/26 2	38·1	·00125
			„ 5	40·1	·00104
			„ 8	39·4	·00119
G.X. 12 V. 25, 36, E. 5	52·0	·00108	95/26 5	41·8	·00112
			„ 13	39·4	·00122

show a wide range of variability from plant to plant. In one case (Plant No. 43/26.5) the lint would actually appear finer than it had been in St. Vincent. In the majority of cases, however, it is considerably coarser, frequently approaching Sakel standards in this respect (*e.g.*, Plants 43/26·4 and 23/26·22). In a few instances it shows itself even coarser, and in the case of 41/26·17 reaches the figure which may be taken normally to represent Upper Egyptian.

The method of sampling employed by us was somewhat different from that employed at the Shirley Institute, Didsbury, but otherwise the technique was similar. Figures from the Shirley Institute appear to give the following values as representing the different types when normally grown:

Sea Island	=	·00112 mgm. per cm.
Sakel	=	·00136 „ „ „
Uppers, Egyptian	=	·00187 „ „ „

In carrying out the work at Shambat we encountered an apparent difference in hair-weight per centimetre between long and short hairs from the same seed, as shown by the following example in which successive " pulls " were taken from the same portion of the seed:

Plant No. H. 9/26 (N.) 50.	*Hair Weight per Cm. in Mgm.*
Long fraction (first pull)	·00174
Med. long fraction (second pull)	·00145
Med. short fraction (third „)	·00129
Short fraction (fourth „)	·00116
Full sample	·00146

This apparent correlation between shortness of hair length and lowness of hair-weight does not agree with the work that has been carried out at the Shirley Institute, and is being further investigated with the friendly assistance of Professor W. E. Morton and the staff of that Institute.

American (N.S.).—The families grown in this plot all originated from the seed of single plants selected from last year's " Observation Plots " at Halfya Meluk. In all cases the parent plants showed some difference from the average plants in those plots, a difference either of kind or degree. The varieties represented were: Delta Webber, Lone Star, Lightning Express, Meade, Columbia. The N.S. families showed no very special improvement on the type, but satisfactory yields were obtained from one family of Lone Star origin. Final selections were made as follows:

From Delta Webber	5 plants for P.L.
„ Lone Star	3 plants for P.L.
„ Lightning Express	2 plants for P.L. and 1 for N.S.
„ Columbia	8 „ „ P.L.
„ Meade	3 „ „ N.S.

American (P.L.).—The parents of these families were also selected from the Observation Plots at Halfya Meluk, and should, strictly speaking, have been tried out in the first instance in " N.S." plots. In view, however, of the fact that they were specially selected as representing the type, as shown by the great majority of plants in these plots, it was considered more convenient to treat them from the start as Pedigree Lines. The origin of the strains from which they were taken was made clear in last year's report, and will not be referred to again here.

The following few notes on this year's families are worth recording for future reference:

Meade.—All families were very late, and in very few cases did they show signs of breeding true. Yield usually low, but fair yield was obtained from A. 3/26 (S). Halo lengths ranged from 27 to 37 mm.

Cleveland.—Nothing special. Short lint (23 mm.).

Columbia.—Nothing special.

Delta Webber.—Most of the families bred true or nearly so. All

were distinctly early and gave fair yields of good quality. Halos long (29 to 31 mm.).

Pedigree Webber.—Rather strong growers. Halos about 26 mm. Ginning out-turn rather high.

Pedigree Dixie.—Vigorous and good yielders, but lint short and variable (24 to 29 mm.), and often rough.

Gendettu.—Late starter, but final yields good. Halo about 30 mm. Decidedly prone to shedding.

Lone Star.—Early and fruitful. Halo 26 to 29 mm.

Durango.—Rather vigorous and fair yield. Shows high tendency to shed. Halo 27 to 31 mm.

Hanik.—Very tall. Late, but good final yield. Lint 29 to 32 mm.

Final selections were made as follows:

Meade	.. ..	5 plants	for P.L and 3 for N.S.
Cleveland	.. .. ..	1 „	„ P.L.
Delta Webber	.. .. ..	11 „	„ P.L. and 3 for N.S.
Pedigree Webber	.. ..	3 „	„ P.L.
Pedigree Dixie	.. .. ..	2 „	„ P.L. and 2 for N.S.
Gendettu	.. .. ..	3 „	„ P.L.
Acala	.. ..	2 „	„ P.L.
Lone Star	.. .. ..	3 „	„ P.L.
Durango	.. ..	2 „	„ P.L.
Hanik	.. ..	2 „	„ P.L.

(4) Hybrid Plot.

In this plot twenty-nine families were grown, and field and laboratory observations made similar to those carried out in the case of the " P.L." plot.

The first eleven families originated from material handed over to me by Mr. Massey. One of these families, H. 10/26, though by no means breeding true, gave good average yields and halos of useful length (34-39 mm.). The lint was whitish in colour and rather harsh. Lint index and ginning out-turn satisfactory. Three plants were selected from this family, whose origin is supposed to be a natural vicinist between Sakel and Sea Island.

All the remaining families represented the fourth generation (F. 4) from a cross made in Egypt between Sakel and Sea Island, the preceding generations having been inbred. Most of these families were still far from breeding true, but some had become almost stabilized as far as vegetative characters at any rate were concerned. These families showed many interesting features, but cannot be dealt with in full detail here. One (H. 22/26) bred true for susceptibility to Thrips attack. Many of the families contained plants with dark brown lint, sometimes associated with length and high quality of

staple. White and Sakel-coloured cottons of good quality have also been noted, and there is little doubt that some of these at any rate can be "fixed." It has been encouraging to note a general tendency to vigour amongst these families as compared with the neighbouring Sakel plants, and detailed records suggest that this vigour is not entirely due to heterosis. Another feature of importance noted was that the ginning out-turn was frequently on the high side—a feature not observed in pure Sea Island. On the whole, the material looks decidedly promising, but in the majority of cases the plants are far from satisfactory in the matter of shedding and boll-opening. The general impression was gained that better results would have been obtained with later sowing. Altogether thirty-five plants were selected from this F. 4 generation for growing-on next year.

New Crosses.—A certain number of new crosses were made during the present year, Sea Island and Upper Egyptian types being used as parents. Both parents in this case may be expected to carry the factors involved in the early production of fruiting branches and in a strongly developed surface-rooting system. Amongst the segregates from this cross it should be possible to find plants which possess the resistance to early shedding shown by the "Uppers" parent, and the length and quality of lint combined with the power of deep root-penetration possessed by the Sea Island type.

(5) New Original Selections.

These have been made both from field crops and propagation plots, and also from amongst the separate families in the breeding plots. In all cases they represent some apparent improvement on the type from which they were selected.

In view of the satisfactory performance as regards yield of the locally established type of American cotton (known as "Pump Cotton") some considerable time has been spent in selecting good individual types from the mixture of which that crop is composed. Some of these latter selections were made from crops in the "rain grown" area, with the particular object of obtaining types useful for those conditions. The following is a list of the new selections made:

American "Pump Scheme"	17
"Meade"	7
"Pedigree Dixie"	6
Various	7
Upper Egyptian	13
Assili (Nahdah and Afifi)	3
Sakel	18
Sea Island: From families grown from Burd's seed	12
Other kinds	23

(6) Propagation.

(*a*) *Small Scale.*—Plots of different varieties were grown at the farm at Shambat, with the object of maintaining nucleus supplies of certain kinds which were either actually in process of trial in variety tests, or considered likely to prove useful in the near future. These plots varied from $\frac{1}{100}$ to $\frac{1}{3}$ feddan in extent, but in all cases a small area was "taped off" in the centre, within which systematic "selfing" of flowers was carried out throughout the season.

The varieties dealt with in this fashion included the following:

American.	*Egyptian.*	*Sea Island.*
Columbia 44	Nahdah	S.I.D. 1, 8.
Delta Webber No. 1	N.T. 25/24	S.I.D. 3, 2.
Pedigree Dixie	Sakel 186/24	
Massey's Gendettu	Bolland Sakel, 8	
Meade E.C.G.C.	„ „ 19·3	
„ B.P.I.	Garofallou	

The origin of these strains has been explained in last year's report.

(*b*) *Large Scale.*—The whole of the cotton area of the Shambat Pump Station, adjoining the Experimental Farm, was sown with the strain of Sakel which was referred to in last year's report as "Massey's Selected Domains," the total amounting to 490 feddans.

A field of 20 feddans in the centre of this area was reserved as a special "roguing area," and was sown, rogued, and picked under the direct supervision of the Plant Breeding Section. The seed from this plot will be used in the coming season for sowing the Main Shambat area, which will in this way come to bear increasingly pure crops of this strain. In addition, seed can be supplied from this source direct to the nucleus plot at Barakat.

As stated in last year's report, this strain of cotton was very favourably reported on by buyers in England, and fetched premiums over the price paid for Sakel of the same grade, which in one case amounted to 200 points.

(7) Spinning Tests.

The results of a first series of spinning tests, carried out by arrangements made through the office of the Empire Cotton Growing Corporation, are now to hand, together with a report on the measurable characters of the same cottons supplied by the British Cotton Industry Research Association. The samples submitted were from the previous season's crop, and the grading and spinning tests support on the whole the decisions made as to the varieties which should be included in this season's American variety tests.

The examination of measurable characters reveals an unusually high proportion of immature or thin-walled hairs in all the samples, a fact which has led to abnormally low hair-weight-per-centimetre figures for this class of cotton. These samples had been, of necessity, ginned out on a small hand gin, and were in many respects unsatisfactory. All ginning of samples will, in future, be carried out on the newly installed full-sized roller gin at Shambat.

Arrangements are in train for spinning tests to be carried out on a wide and representative series of samples from the current year's crop, from which it is hoped, *inter alia*, to obtain valuable information as to the effect of the date of picking on the quality of the cotton picked, a question which is of the very highest importance in the Sudan, where the picking season at present extends right through from the comparatively cool winter to the excessively hot and dry months of April and May.

We are deeply indebted to the British Cotton Industry Research Association, as well as to those individual Spinners and Brokers who have so kindly devoted a considerable amount of time and labour to our problems, and without whose co-operation it would be impossible for us to obtain that information as to the actual behaviour of the cotton in the mill, which is the final criterion of success or failure.

(8) Developmental Observations on Cotton Plants.

(*A*) *Plants Grown in Boxes.*—The work alluded to in last year's report has been continued, and a complete monthly series of Egyptian (Sakel) and American plants has been sown and grown throughout the year in large wooden boxes. A record, as complete as time permitted, has been kept of all developmental characteristics exhibited by the plants, together with observations on soil temperature. The records made included such points as rate of germination, rate of laying down of nodes, position of origin of the first fruiting-branch, rate of development of buds along the branches, degree of shedding of branches, buds, and bolls, extent and location and orientation of growth of monopodial branches, and notes on the direct observable effects of specially rigorous environmental conditions, such as sandstorms or periods of exceptionally high or low temperature. The experiments are still in progress, and it is hoped to embody the final results in a paper specially devoted to this subject. The following are some of the points of interest noted:

(*a*) Rate of germination, as measured by the interval between sowing and the appearance of the cotyledons above the soil, varied very much according to the season, the longest interval (eight days) being recorded in mid-January, and the shortest (three days) during the months of May, June, and July.

(*b*) The time taken for individual flower buds in the case of Sakel cotton to develop from their primordia varied by several days at different periods of the year, thus disagreeing with observations made in Egypt. It should be noted, however, that the Egyptian observations referred only to the summer season in that country.

At Shambat the total maturation period of buds developing during the period December to early February was in the neighbourhood of fifty-one days (very approximately), whereas that for buds developing in the hot period between mid-March and early May was, very roughly, about forty-six days. Both these periods are notably longer than the period estimated for Sakel in Egypt, which was forty-two days only, the conditions of growth being similar as regards the size of the boxes. Much variation was also found to occur at Shambat in the length of the period during which the sympodium internodes continued to elongate. Our data on this point are not sufficiently numerous, but as they stand they do not give any clear indication of seasonal differences in this respect.

(*c*) The extent and kind of development of monopodial branches has been found to depend to a surprising extent on climatic influence. This may be roughly summed up in the case of Sakel plants as follows:

August to October sowings produce, near the base of the plant, a few large monopodial branches which are carried almost horizontally.

January sowings produce large basal monopodia (slightly more in number than the foregoing), which grow out horizontally for about one-third of their length, and then, when the weather becomes really hot, turn upwards and continue their growth almost vertically.

March to May sowings produce twice or three times the number of branches, which tend to start a little higher up above the level of the cotyledonary node, and are carried much further up the stem. These branches are not so stout as those which started in the winter months, and are strikingly vertical in direction of growth from the very start.

(*d*) The most striking seasonal effect of all is the behaviour of the fruiting branches, the growth of which appears to be actually inhibited during the hotter periods, especially in the case of Sakel cotton.

Sakel sown in October behaves in this respect very much as it does when grown during the normal cotton season in Egypt; in other

words, it produces good-sized effective fruiting branches from the eighth axil of the stem upwards. As the bolls on these come to maturity the plant enters a resting stage, and then enters a second period of fruiting branch production of similar but rather less vigour than the first. Both these periods of bud-formation fall within the cold or reasonably cool season of the year.

With plants sown in mid-March the case is somewhat different. Fruiting branches tend to start fairly low down as their early development takes place before the hot weather has properly set in. After that the plant carries on producing branches of irregular length, usually short, and often failing altogether.

The extreme case is shown in May-sown plants, which are met with the hottest of weather from the very beginning. Here we find that fruiting branches are not produced at all, but the plant goes on growing until the short rainy season produces more favourable conditions. A start is then made—perhaps as late as the twenty-fifth node on the main stem—and a few fairly well formed branches produced at the top of a tall leggy plant, but with the renewed onset of the hot weather after the rains cease this belated attempt is abandoned.

The importance of a recognition of this behaviour as regards time of planting is obvious.

(*B*) *Root Development.*—A series of observations was carried out in order to obtain an insight into the subterranean factors on which the aerial growth in great measure depends. In particular it was desired to discover, if possible, whether the different types of aerial habit shown by varieties, and their varying response to the climatic environment were in any way connected with differences in their root systems. The experiments were conducted by sowing Sakel, Upper Egyptian, Sea Island, and American types in the same plot, and digging out the root systems of a certain number of plants every month for five months. These special observations were supplemented by the digging out of other plants in various parts of the farm for comparison. The results have not yet been fully worked up, and the influence of small local irregularities in soil conditions has confused the issue to some considerable extent, but, given the normal Shambat soil conditions with a layer of very heavy soil lying at about half a metre below the surface, it would appear that the plant-roots reach this layer by the end of the first month's growth. The second month appears to be spent in more or less unsuccessful attempts to penetrate this layer, with considerable abortion of root tips. At the same time a great extension in lateral growth above the " pan " layer takes place. In the third month great extension

in length of the laterals tends to take place and attempts at depth penetration continue, the result of which is either failure or some slight measure of success. In the latter case considerable development, both vertical and horizontal, takes place during the fourth month in the more sandy soil underlying the "pan." The surface system during this time branches and thickens up. The difficulty experienced in forcing a way through the pan is clearly seen in the roots themselves, which in this zone are thin, hard, and much contorted.

Certain varietal differences appeared in the relation of the plants to this hard layer of soil. Upper Egyptian plants had a particularly poor power of penetration, but were characterized by very long, stout, branching laterals in the upper layers (doubtless connected with the tendency of this variety to go "thirsty" sooner than others). Sea Island has an almost equally well developed surface system, but combines with it a considerable power of depth penetration. Sakel appears to occupy an intermediate position in both respects, and the root system as a whole appears rather to lack vigour. The American plants examined (Delta Webber) had roots of altogether distinct "texture" and colour. Laterals were as a whole poorly developed, and the plants seemed to have suffered considerably in those cases where they failed to penetrate the pan. It would seem possible that growth in depth is essential to this kind, and it may be the reason for the poor performance put up by American cotton on the Shambat Farm. It is hoped that, as our knowledge of this subject increases, it may in time be possible to predict with some chance of success the behaviour of the plants under a variety of conditions, and to make recommendations that certain varieties should be grown in certain situations and areas.

(9) Early Topping Experiment.

This experiment was undertaken as a side-line, and arose out of the developmental observations on fruiting branches which have been already described. Topping has often been carried out in cotton, but, as far as I am aware, it has always been done in the case of rather rank growth and at a time when the crop has already started to set on the lower branches.

The considerations which led to the present experiment being carried out were as follows: Observations on "box plants" show that the conditions are especially favourable for bud formation in October and November. If, however, planting is delayed as late

as would seem necessary, another factor comes in—namely, actual cold with its attendant slowing-up of all the vegetative and reproductive processes (direct *damage* from low temperatures is probably of very rare occurrence). It would seem possible that the ideal might be achieved by planting in, say, August, and allowing the plants to get well established, and then cutting right back to the fourth or fifth node at a time which would allow the new branches which are produced to start their growth under the optimum conditions. In this way we should get well-formed root-systems, each bearing three or four strong shoots above ground, which should be able to settle down at once to the business of flower- and fruit-production under the most advantageous circumstances.

The experiment in this last season was carried out on Sakel sown on July 19. Two different times were chosen for topping—namely, four weeks and six weeks after sowing—all the plants being cut away above the third leaf-axil in each case. Four repetitions of each time of cutting were made, and ten beds left as controls. The experiment was not sufficiently conclusive, but showed, if anything, a slight additional yield (4 per cent.) from the beds topped one month after sowing. The yield from the late-topped beds was less than that of the control. A similar trial will be made in the coming season.

Conclusion.

The results obtained in the various investigations detailed above appear to justify a continuation of the work along the same lines. In particular, an effort will be made further to improve the system of taking serial records in connection with Variety Test Plots, as this has proved itself to be of real value in interpreting the results obtained.

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